DIMENSIONS NBS

The magazine of the
National Bureau
of Standards
U.S. Department
of Commerce

February 1977

ENERGY CONSERVATION. See page 2.

COMMENT

MEASURES FOR THE NATION

Measurement is so much a part of daily life that most people take it for granted. We don't. Measurement is a major reponsibility of the National Bureau of Standards, and in the Institute for Basic Standards, it is our overriding concern.

Accordingly, we have assigned high priorities to a number of major physical measurement problems in order to meet national needs. These include:

- uniform measurements of ionizing radiation, electromagnetic radiation, and acoustical noise;
- uniform measurements for telecommunications and micrometer and submicrometer structures; and
- uniform measurements to monitor solar radiation and spectral transmission of the atmosphere.

From our priorities, you can tell that this institute (IBS) is deeply involved in sophisticated science. However, the research we conduct and the services we provide relate to every event in what we call a national system of measurement—including these common activities: buying grocery items accurately weighed or measured by volume; using electric power and gas which are measured by meters with accuracy traceable to NBS standards; buying cars mass-produced on assembly lines from standard parts whose dimensions are controlled by gage blocks ultimately traceable to NBS; and buying light bulbs whose light output is implicity governed by comparison to NBS photometric standards.

These examples illustrate how, on the national level, accepted standards of measurement make possible an orderly marketplace and the assurance of equity between buyer and seller. They also permit the development of markets with the economy of large-scale mass production and the resultant benefit to the consumer. On the international level, the coordination of this country's measurement system with measurement systems of other nations is becoming increasingly important as our industrial and commercial interests in foreign markets continue to grow.

This coordination is handled by IBS—just as we also provide the foundation of this nation's measurement system and furnish the services necessary to support it. Our role is to assure that all physical measurements can be made reliably at the needed levels of accuracy and at reasonable cost.

The United States' national standards of measurement are based conceptually on the base SI (International System) units. The standards for these base units for mass, length, time, temperature, electric current, and luminous intensity are developed and maintained in IBS and serve as the basis for the internationally agreed upon systems of units. In principle all the other units can be derived from these few; in practice it is easier and more economical for us to develop and maintain derived units as additional national reference standards, for example, standards for force, electric power, pressure, and radiant flux.

We hold recognized worldwide leadership in theoretical studies and laboratory experimentation—the areas we utilize in selecting, designing, constructing, and operating our national standards and dissemination mechanisms. Standards are developed and improved on the basis of the latest advancements in science and technology and disseminated as required to meet the changing needs of science, industry, commerce, and the general public. Dissemination programs such as our test and calibration services, our measurement assurance programs to evaluate the quality of measurement procedures in the field, and our publication of benchmark data are typical examples of direct contact with the users of the work performed in IBS. Through our work in developing new measurement techniques, we will continue to advance our ability to meet the needs of the nation for measurement services now and in the future.

Arthur McCoubrey

Arthur McCoubrey
Director, Institute for Basic Standards

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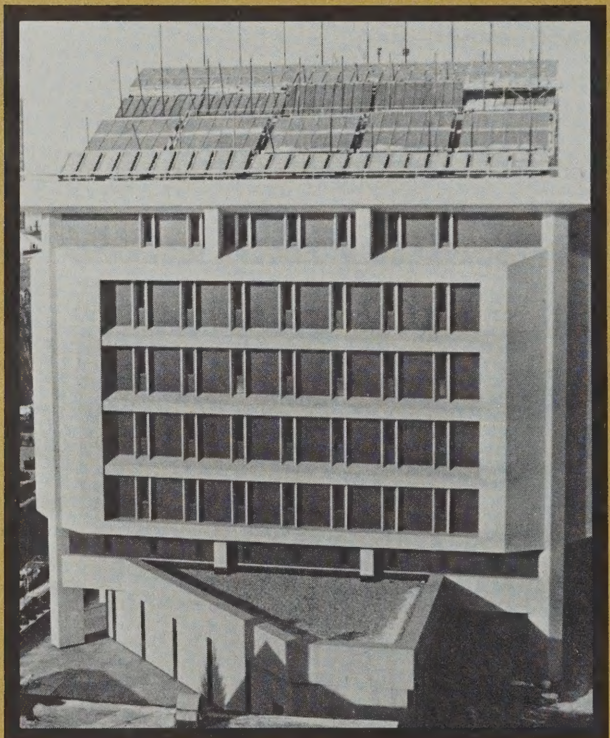
NEW ENERGY EFFICIENT OFFICE BUILDING



South view of the Norris Cotton Building, showing array of solar collectors. Vertical poles rising from the collectors adjust the collectors from a 20 degree to an 80 degree tilt as the seasons change to take full advantage of the sun's angle.

PROVIDES LIVING LABORATORY

by *Madeleine Jacobs**

COVER STORY:

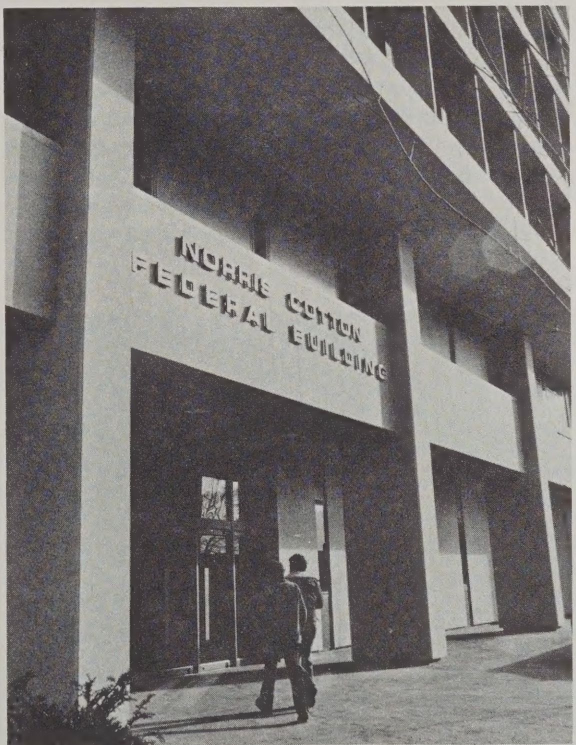
The Norris Cotton Building, a General Services Administration office building in Manchester, New Hampshire, is the first in a new generation of energy conserving buildings, designed from the beginning with energy efficiency in mind. The National Bureau of Standards is monitoring the building for its energy consumption. The results are expected to aid architects and engineers in the future design of energy-efficient public buildings.

IN Manchester, New Hampshire, nearly 400 federal employees go to work every day in a unique building. Although it has been occupied only six months, the $8.7-million office structure, with its nearly cubical shape and its large rooftop array of solar collectors, is already a landmark on the city's skyline. Inside, there are innovative lighting and climate control systems on each of the seven floors. Throughout the building, a sophisticated complex of sensors and gages silently monitors the building's performance at more than 750 stations. Only a control panel in the lobby indicates that something really unusual is going on.

In actuality, the building is a living laboratory in which the latest energy conservation technology is being tested. The General Services Administration (GSA), landlord for the federal government, views it as the first in a new generation of energy-conserving buildings. At the very least, it is the first federal building that was designed from the beginning with energy efficiency in mind. And it will be the first to be thoroughly monitored for its energy consumption. The results of the monitoring are expected to aid architects and engineers in the future design of energy-efficient public buildings.

"Designing any office building is always difficult, but designing an energy-efficient building was a new challenge," says Dr. Tamami Kusuda, chief of the Thermal Engineering Section at the National Bureau of Standards, Center for Building Technology. "NBS was involved before it was even designed." The building was conceived as the offspring of a GSA/NBS roundtable in 1972, which was organized by Dr. James R. Wright, then director of CBT and currently acting director of the Institute for Applied Technology. The roundtable brought together engineers and architects from government, industry, and professional associations. Shortly afterward, GSA designated the building as an energy conservation pilot project to demonstrate the effectiveness of a variety of conservation measures. GSA put together a team of experienced architects, engineers, and consultants. Among them was engineer Kusuda, chosen for his experience with computerized energy performance analysis of buildings.

Computer simulations are routinely used by engineers to predict heating and cooling performance of buildings, Kusuda explains. "Inaccurate load calculations lead to overdesigned heating and cooling equipment that uses too much energy and operates at lower efficiency," he says. "Most available computer programs are not suitable for analyzing designs where non-conventional or innovative ideas on structures, heating and cooling systems, and controls are employed." Kusuda developed an advanced and sophisticated computer program, called National Bureau of Standards Load Determination (NBSLD), that overcame these obstacles and enabled the merits of various building construction systems to be compared and evaluated.



"We studied more than three dozen design options using NBSLD," Kusuda recalls. "Obviously, all possible systems considered to be energy efficient could not be included in a single small demonstration project. But the computer studies enabled the design team to evaluate the choices and trade-offs and 'put it all together'. The results were used directly by the GSA architects and engineers to choose the most effective designs, materials, and heating, cooling, and ventilating equipment. From these studies we also estimated that this building would use at least one-third less energy than con-

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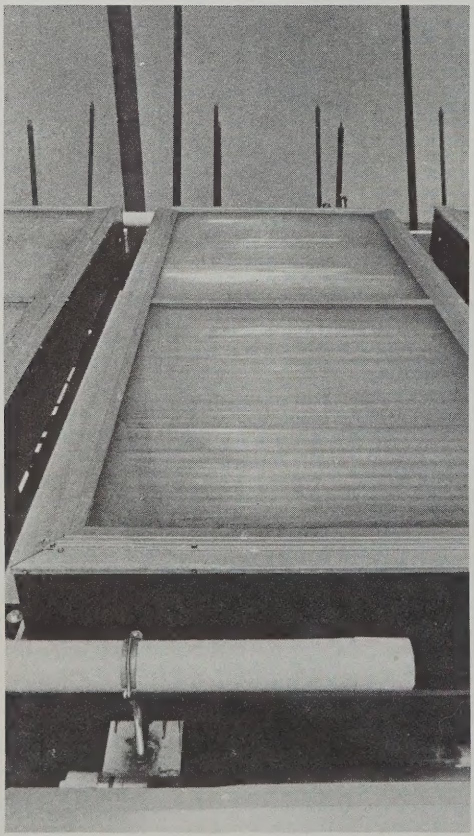
* Jacobs is a writer and information specialist in the NBS Office of Information Activities.

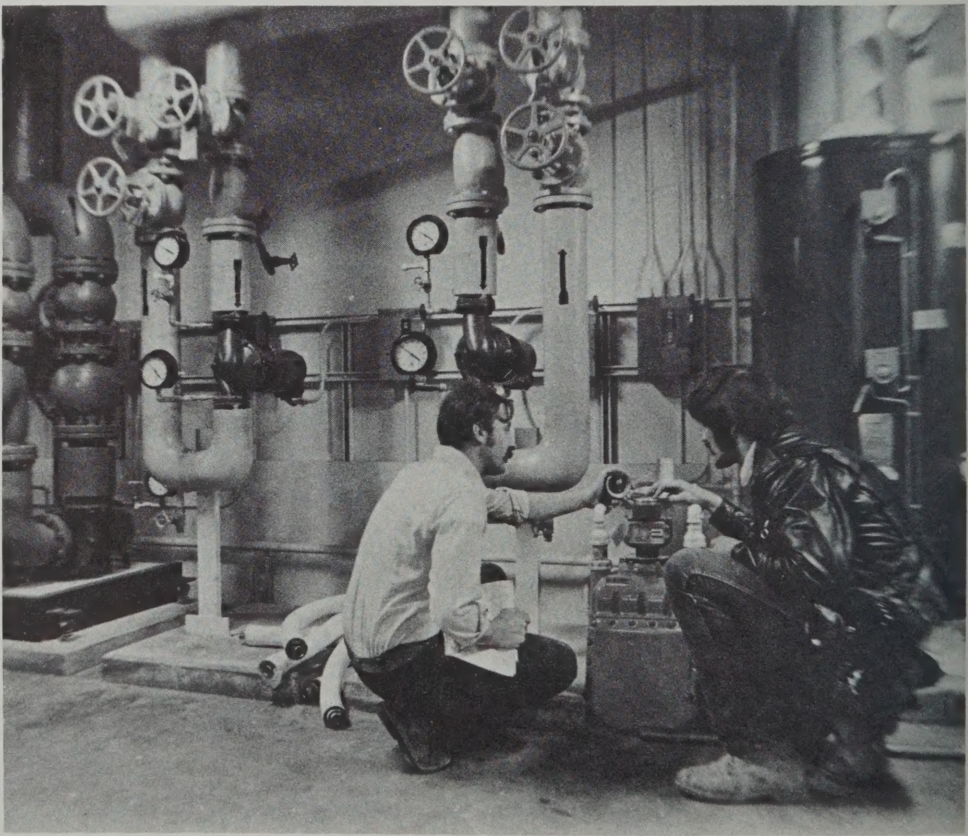
ventional structures of comparable size." Construction began in 1973 and the office complex was officially dedicated as the Norris Cotton Building on October 8, 1976.

Kusuda notes that the building actually combines dozens of energy-conserving features that were already available commercially (there are no real breakthroughs) but that had not been validated in the field. One of the building's most striking features is its nearly cubical shape. "This minimized exterior surface areas," Kusuda explains, "which are normally the greatest source of heat loss, especially in a northern city such as Manchester." Next, it was determined that the window areas should be limited in size on the east, west, and southern exposures of the building. The north wall has none at all. "Normally, the total lack of windows might be depressing to employees," Kusuda says, "but not in this situation because the service functions such as elevators, storage closets, and bathrooms have been placed against the north wall. The combined effect is that the building is well protected against the large heat loss normally encountered on the northern facade of a building.

The windows are smaller than in most conventional buildings and closer to the ceiling so that light enters from above. This makes it possible to maximize the use of daylight through small windows. The windows also are double-glazed and designed to limit air leakage and heat transfer. There are other provisions to take advantage of heat transfer. For example, fixed fins on the building exterior shade the windows in summer but allow the lower winter sun to pass through, reducing the load on the heating system.

Other basic departures from conventional design are incorporated in the construction of the external shell, which has a heavier wall construction to minimize the effects of outdoor temperature and other changes in the weather. "A somewhat unusual feature is that insulation is on the outside of the masonry material rather than on the inside," Kusuda notes. "This creates a thermal well that absorbs heat from the interior and returns it to the





Opposite page, left to right. Close-up of one of the solar panels on the roof, showing convection suppressors on the surface to reduce heat loss and screw-jacks at the top for tilting the angle. Building Automation Engineer Ron Breault (left) and Electrical Supervisor Wayne Albert discuss gas-fired boilers on top floor of building. Because of the solar energy systems and the energy efficiency of its overall design, the building needs only a fourth or fifth of the heating capacity of a conventional structure. Top. Resident Engineer Dick Low is shown under the structural framework and connecting piping of the solar collectors. Bottom. On the roof of the building, Low (left) and Albert confer at the foot of the solar panels. At their left are the pyranometers which sense incident solar radiation on the panels. At right is a pyrheliometer which tracks the sun from dawn to dusk, sensing direct beam radiation. Data from the two devices will be used by NBS engineers to analyze performance of the collectors.

space during periods when interior climate conditioning is not in operation. This means that the peak cooling requirement can be much smaller."

The interior of the building is an "open landscape" environment with a limited number of ceiling-high partitions. Where it was necessary to enclose rooms, the architects grouped together functions requiring the same kinds of conditions. The prime benefit from grouping like functions together is the consolidation of mechanical delivery systems for heating, ventilating, and air conditioning purposes.

The laboratory nature of the building is apparent in the various energy-efficient heating, cooling, and lighting systems installed on different floors so that their relative performance can be compared. For example, four variations of heating and cooling delivery systems are used to control the temperature in the top four stories. Three variations of a heat-pump system provide heating and cooling for the lower three floors.

Different energy-efficient lighting systems are

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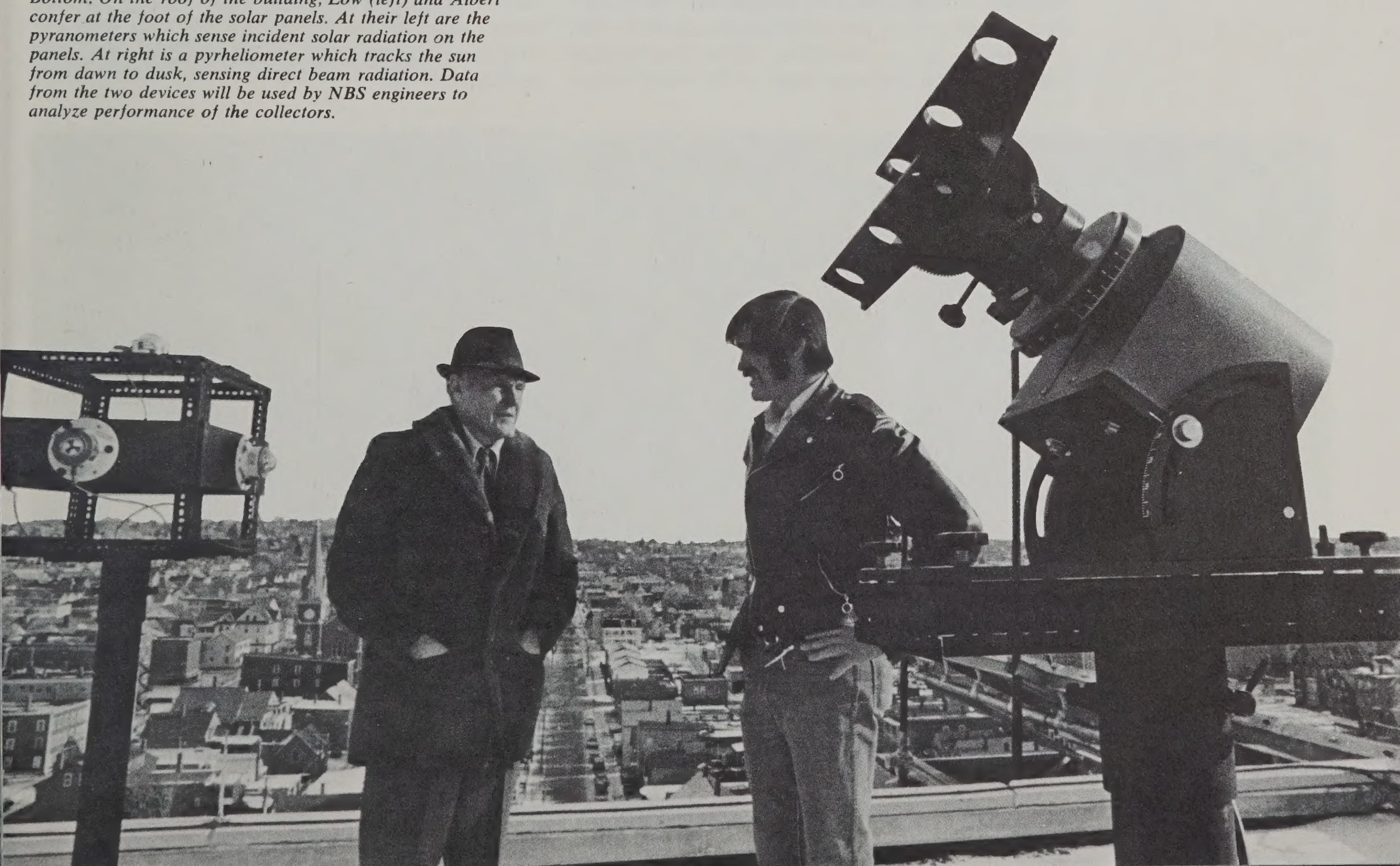


provided for each level. The third floor is equipped with polarized lights and the fourth has high-pressure sodium vapor lamps. The second story is a testing area for natural lighting and has larger windows than the other areas. Photoelectric override devices prevent use of artificial lighting if natural light is sufficient. The second-floor lighting will be compared to that on the sixth floor, which employs similar fixtures but has less window area.

Unusual office furniture with its own built-in lighting systems is located in a test area on the fifth floor where no overhead fixtures are provided. This system should significantly reduce energy consumption by concentrating light in work areas rather than wastefully illuminating areas not in use. The furniture groups include desks, chairs, shelves, closets, and file cabinets.

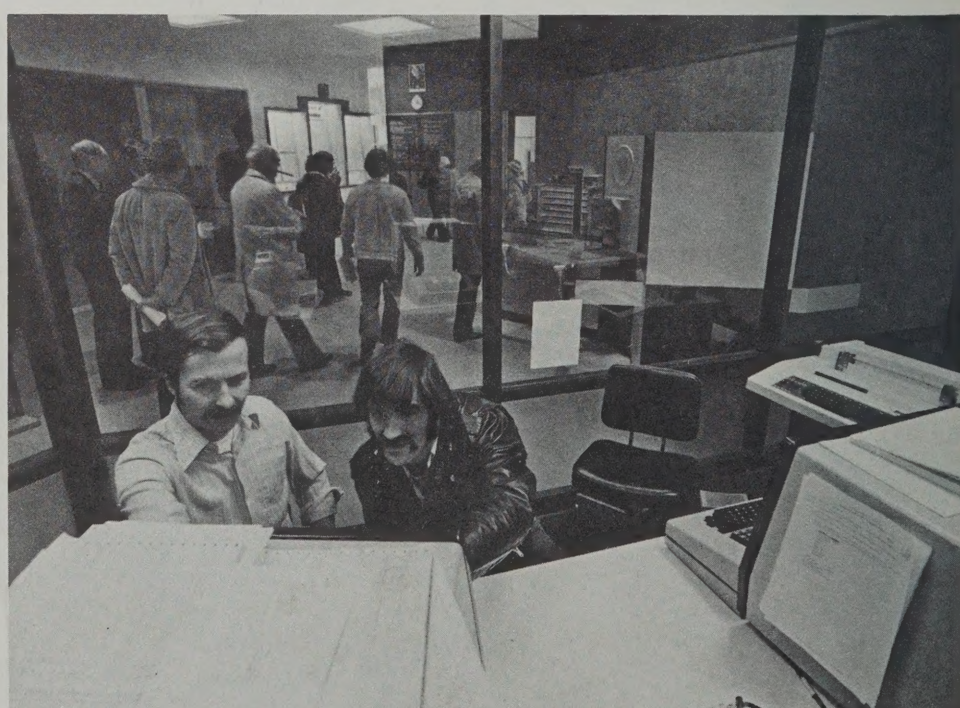
The building is also equipped with a heat recovery system so that heat produced and normally wasted by the mechanical heating and lighting systems is collected and stored for later use.

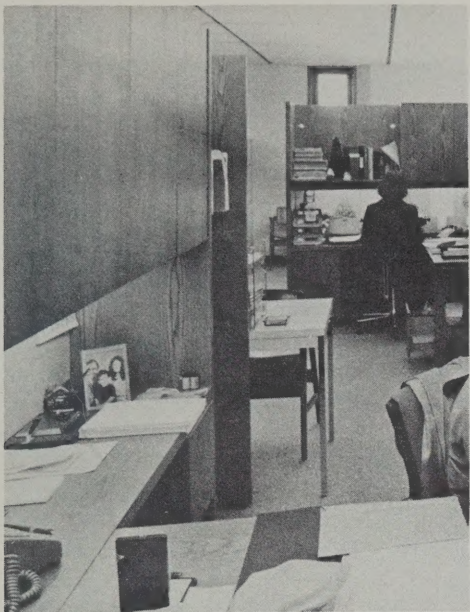
Another important feature is the solar energy system. The building is outfitted with 414 square meters of roof-mounted solar collectors. The panels are arranged in four rows and can be adjusted from a 20-degree to an 80-degree tilt as the seasons change to take full advantage of the sun's angle. GSA believes the system is the first in a commercial building to employ tilt-angle adjustments. The solar energy system, funded with a grant from the Energy Research and Development Administration (ERDA), is designed to furnish nearly all the energy needed to heat and cool the building in moderate weather. However, the system is expected to provide, on the average, about 20 to 30 percent of the total energy required for hot water and heating and cooling.

Because of the solar energy systems and the energy efficiency of its overall design, the building needs only a half to a third of the cooling capacity and a fourth or a fifth of the heating capacity of a conventional structure.

How well the office complex actually lives up to its billing as an energy-efficient building will be determined in the next three years, as NBS undertakes an extensive evaluation for GSA. The evaluation project is funded by ERDA. Working with GSA, NBS designed and supervised the installation of an extensive monitoring instrumentation system that will be used to record the building's energy consumption and the performance of solar and other systems. Dr. James Hill of the Thermal Engineering Section will be leading the NBS evaluation.

Above. At the push of a button, the current status of any given system in the building can be determined by looking at the read-out on the console. Right. Breault (left) and Albert discuss the day's problems in computer control room on the first floor of the building.





Within the building there are about 750 sensors that measure seven parameters: temperature, humidity, air and water flow, solar radiation, electric power consumption, barometric pressure, and indoor illumination. The sensors are electrically connected and controlled by a commercially available building monitoring and control system that has been modified to NBS specifications for this project. These data points are scanned every 20 seconds. At the end of each one-hour cycle, all data are averaged and converted into engineering units (such as degrees Celsius, watts per square meter, etc.) and stored on magnetic tapes.

"Then the tapes are sent to NBS laboratories in Gaithersburg, Md., to be processed through the NBS computer," Hill explains. "From this we get a variety of useful information. For example, we get a weekly summary of building energy consumption, with and without solar energy included; a prediction of energy consumption for a hypothetical conventional building undergoing the same exterior conditions and maintaining the same interior environment; a summary of the equipment performance (efficiency, energy consumption); a magnetic tape copy of the weather data; and an indexed magnetic tape of all data.

"With this information in hand, we can make a

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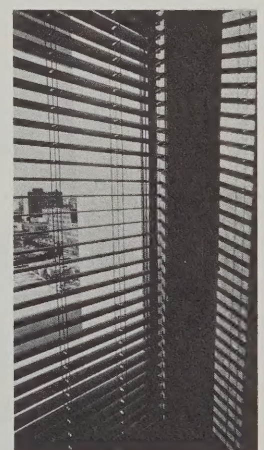
Top. Office furniture with built-in lighting is located in a test area on the fifth floor where no overhead fixtures are provided. This should reduce energy consumption by concentrating light in work areas rather than illuminating areas not in use. Center. Overhead lighting on the sixth floor. Bottom. The second story of the building is a testing area for natural lighting and has larger windows than other areas. Photoelectric override devices prevent use of artificial lighting if natural light is sufficient. The second floor lighting will be compared to that on the sixth floor, which employs similar light fixtures but has less window area.



Above. Windows in the Norris Cotton building are smaller than in most conventional buildings. The windows also have venetian blinds between the layers of the double glazed glass to allow occupants to control natural light and heat through the windows.

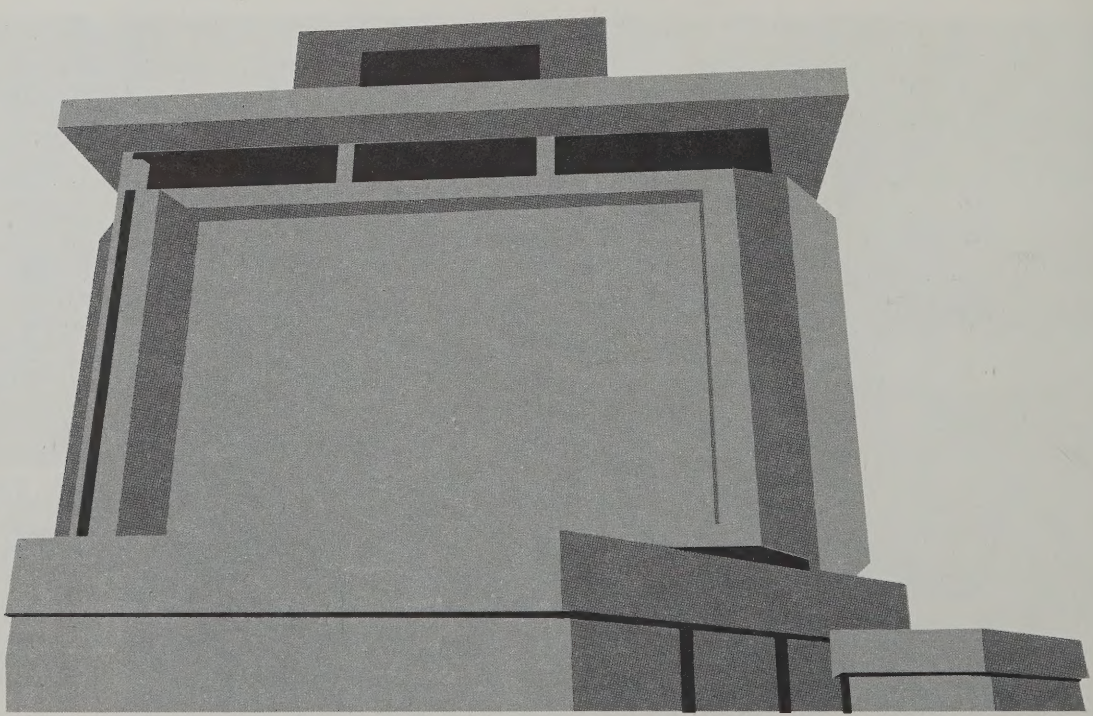
detailed examination of energy use," Hill says. We'll be able to tell which features are the most efficient. In addition, the information, such as the weather tape, will be used to evaluate the energy-consumption calculation procedures we used and to indicate variations between predicted and measured values." He adds that employee reaction to the building's environmental systems, such as lighting and window space, will be studied by NBS psychologists.

In all, a team of nearly half a dozen NBS engineers and scientists will be engaged in various aspects of the evaluation. The findings will be made available to the public, especially builders and architects, as the study progresses. Not only will this be useful in solving future design problems, but the data will also help in analyzing the usefulness of computer studies for designing energy-efficient buildings.

Even before the evaluation is completed, GSA, which operates about 10,000 federal buildings, is incorporating many of the Manchester features in structures that are now being designed. In particular, GSA Administrator Jack Eckerd notes that the feasibility of including solar energy is now being considered in the initial design of all new federal buildings. "Solar energy is not a panacea, but its prospects are exciting," he says.

Eckerd feels just as strongly about the need to conserve energy in existing buildings. "Designing new energy-efficient complexes like Manchester is important," he notes, "but we must also turn our attention to saving energy in existing buildings. After all, 85 percent of the structures that will be operating in the year 2000 have already been built. Energy conservation is not a luxury; it's a necessity."

Meanwhile, the Norris Cotton offices are a bright promise of things to come. By 1979, GSA expects to have more than 20 such complexes in operation, with an annual energy savings of more than $3 million. Says Eckerd, "The Manchester building is the first of its kind, but it represents a new generation designed to meet the challenge of the energy crisis." □



Two of the building's most striking features are its nearly cubical shape and windowless north wall, which minimize heat loss from the surface.

METRIC
STYLE GUIDE

THE National Bureau of Standards has been a focal point for metric information since 1971 when it produced a 13-volume set of metric reports for the Congress. Since then NBS has maintained a Metric Information Office to respond to requests. Many of these functions will be assumed by the U.S. Metric Board, a separate entity established by the Metric Conversion Act of 1975.

When President Ford signed the Act on December 23, 1975, the United States established for the first time a national policy to coordinate the use of the metric system in this country. This policy will become evident over the next few months and years as more and more U.S. businesses, industrial firms, schools, and government agencies adopt the metric system. Every American will be affected by the changeover.

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Metric Style Guide

Most Americans will need to know only a few metric units for everyday activities. In most cases, familiarity with the following metric units will be sufficient for everyday transactions:

	Name	Symbol	Approximate Size
length	meter	m	39½ inches
	kilometer	km	0.6 mile
	centimeter	cm	Width of a paper clip
	millimeter	mm	Thickness of a paper clip
area	hectare	ha	2½ acres
weight	gram	g	weight of a paper clip
	kilogram	kg	2.2 pounds
	metric ton	t	long ton (2240 pounds)
volume	liter	L	one quart and 2 ounces
	milliliter	mL	1/5 teaspoon
pressure	kilopascal	kPa	atmospheric pressure is about 100 kPa

Units of **time** and **electricity** will not change.

The Celsius **temperature** scale should be used, familiar points on which are:

	°C	°F
Freezing point of water	0	32
Boiling point of water	100	212
Normal body temperature	37	98.6
Comfortable room temperature	20-25	68-77

Prefixes

Some of the metric units listed above include prefixes such as kilo, centi, and milli. Prefixes, added to a unit name, create larger or smaller units by factors that are powers of 10. For example, add the prefix kilo, which means a thousand, to the unit gram to indicate 1000 grams; thus 1000 grams becomes 1 kilogram. The more common prefixes are shown in Table 1.

Conversions

Conversions should follow a rule of reason: don't include figures that imply more accuracy than justified by the original data. For example, 36 inches would be converted to 91 centimeters, not 91.44 centimeters (36 inches x 2.54 centimeters per inch = 91.44 centimeters), and 40.1 inches would convert to 101.9 centimeters, not 101.854. Table 2 lists many of the more commonly used conversion factors.

Spelling

All units and prefixes should be spelled as shown in this guide.

Capitals

Units: The *names* of all units start with a lowercase letter except, of course, at the beginning of the sentence. There is one exception: in "degree Celsius" the unit "degree" is lowercase but the modifier "Celsius" is capitalized.

Symbols: Unit symbols are written in lowercase letters except for liter and those units derived from the name of a person (m for meter but W for watt, Pa for pascal, etc.).

Prefixes: Symbols of prefixes that mean a million or more are capitalized and those less than a million are lower case (M for mega, k for kilo).

Plurals

Units: Names of units are made plural only when the numerical value that precedes them is more than 1. Zero degrees Celsius is an exception to this rule. For example, 0.25 liter or 1/4 liter but 250 milliliters.

Symbols: Symbols for units are never pluralized (250 mm = 250 millimeters).

Spacing

A space is left between the number and the symbol to which it refers. For example 7 m, 31.4 kg.

In names or symbols for units having prefixes, no space is left between letters making up the symbol or name. Examples: milligram, mg; kilometer, km.

Period

DO NOT use a period with metric unit names and symbols except at the end of a sentence.

Decimal Point

The dot or period is used as the decimal point within numbers. In numbers less than one, a zero should be written before the decimal point. Examples: 7.038 g; 0.038 g.

Pronunciation

The pronunciation of the common metric units is well known except for pascal which rhymes with rascal and hectare which rhymes with bare. Celsius is pronounced sell-see-us.

The first syllable of every prefix is accented, not the second syllable. Examples: kilometer as in kilowatt; centimeter as in sentiment.

For More Detail

Approximate conversions for many units are given in Table 2. Some writers will require detailed information on units peculiar to their fields. For example, the British thermal unit, calorie, and therm are replaced by the metric unit, joule. Further information is available in "NBS Guidelines for Use of the Metric System," LC1056, free, from the Metric Information Office, National Bureau of Standards, Washington, D.C. 20234, 301/921-2658. Also useful is the "NBS Metric Kit," (SP410), complete with references, charts, a conversion card, and the history of the metric system, available from the Superintendent of Documents, Government Printing Office, Washington, D.C 20402; price: $2.

This material is reprinted from the NBS brochure titled *Metric Style Guide For The News Media.* Single copies are available free of charge from the National Bureau of Standards' Office of Information Activities, Administrative Building A621, Washington, D.C. 20234. Organizations may obtain negatives of the brochure for reprinting. □

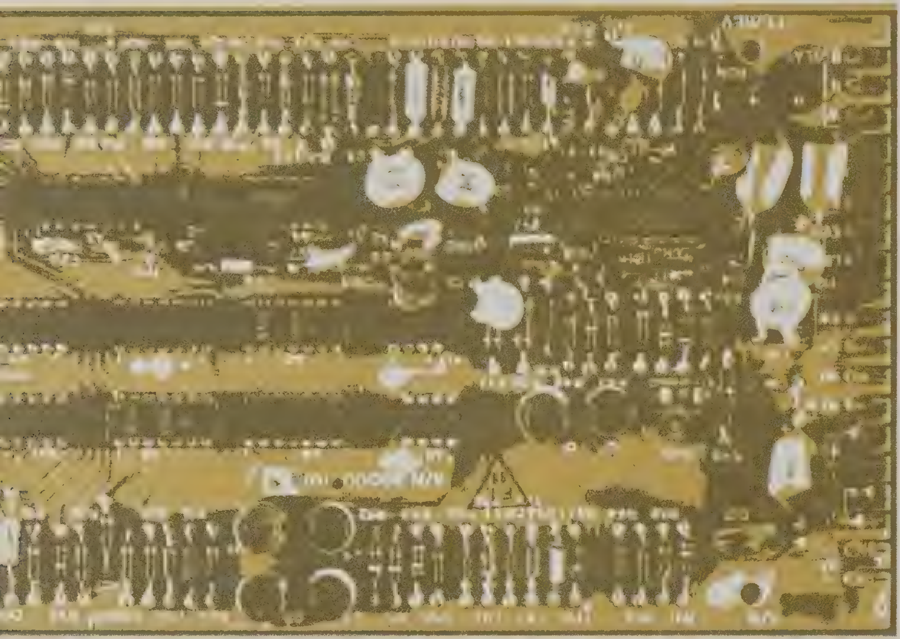
Table 1 COMMON PREFIXES FOR METRIC UNITS

Factor		Prefix	Symbol
1 000 000	10^6	mega	M
1000	10^3	kilo	k
1/100	10^{-2}	centi	c
1/1000	10^{-3}	milli	m
1/1 000 000	10^{-6}	micro	μ

Table 2 METRIC CONVERSION FACTORS (Approximate)

	Symbol	When You Know Number of	Multiply By	To Find Number of	Symbol
LENGTH	in	inches	2.54	centimeters	cm
	ft	feet	30	centimeters	cm
	yd	yards	0.9	meters	m
	mi	miles	1.6	kilometers	km
AREA	in^2	square inches	6.5	square centimeters	cm^2
	ft^2	square feet	0.09	square meters	m^2
	yd^2	square yards	0.8	square meters	m^2
	mi^2	square miles	2.6	square kilometers	km^2
		acres	0.4	hectares	ha
WEIGHT (mass)	oz	ounces	28	grams	g
	lb	pounds	0.45	kilograms	kg
		short tons (2000 tons)	0.9	metric tons	t
VOLUME	tsp	teaspoons	5	milliliters	mL
	Tbsp	tablespoons	15	milliliters	mL
	in^3	cubic inches	16	milliliters	mL
	fl oz	fluid ounces	30	milliliters	mL
	c	cups	0.24	liters	L
	pt	pints	0.47	liters	L
	qt	quarts	0.95	liters	L
	gal	gallons	3.8	liters	L
	ft^3	cubic feet	0.03	cubic meters	m^3
	yd^3	cubic yards	0.76	cubic meters	m^3
PRESSURE	inHg	inches of mercury	3.4	kilopascals	kPa
	psi	pounds per square inch	6.9	kilopascals	kPa
TEMPERATURE (exact)	°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius	°C

The MEASUREMENT CHALLENGE In Electronic Technology



by Judson C. French*

IS the United States losing its technological leadership? That question is being raised frequently. At the EASCON meeting of the Institute of Electrical and Electronics Engineers last fall, a panel of experts concluded that the country is in serious danger of doing so. Their examples of U.S. failures to be competitive internationally in the manufacture of certain electronic components and circuits were startling. Many other leaders in industry and government have expressed similar concern not only about the loss of technological leadership, but also about the loss of economic and military leadership, both dependent on technological ascendancy. For example, members of management in 13 electronics companies unanimously agreed that a problem exists—a problem not in creativity but in how to make things better from a standpoint of productivity and quality. They cited semiconductor technology as one area requiring careful attention.

One of the major factors in the expansion of electronics into industrial, consumer, and government applications is the rapid development of semiconductor components on which most electronic "systems," from cardiac pacemakers to computer networks, now depend. Active electron devices, such as semiconductors, largely make possible, and also limit, the capabilities of such systems. As go components, so goes the system.

Silicon-based semiconductors have been the pacesetters for years and will continue to be so for the foreseeable future. Other technologies are important in special cases, but comments involving silicon devices as an example will apply equally well to them.

The measurement problem in this field can be summed up by saying that despite (or perhaps because of) the sophistication of semiconductor technology, the measurement methods available to control materials and equipment as they enter and are used on a production line, and the measurement methods to characterize the finished product, are all too often not sufficient to meet the needs of the supplier or the customer. Semiconductor technology has outdistanced traditional metrology. This is true across the board, from chemical measurements, through dimensional metrology, to electrical tests.

Hundreds of companies confront this problem to an increasing extent in U.S. industry. Manufacturers of products as diverse as computers, cameras, automobiles, cardiac pacemakers, and electronic instruments now make these semiconductor components in-house for economic and competitive reasons. These companies must interface with the thousand suppliers of materials and equipment needed for semiconductor manufacture and must control the manufacture of their own products and characterize them, perhaps even more carefully than must the merchant manufacturers of devices.

Many persons today are familiar with the development of tiny, complex integrated circuits that contain thousands of individual transistors on a silicon chip only a few millimeters square. These devices already require crystal purity and perfection, purity of processing gases and chemicals, and dimensional controls for photolithographic processes far beyond those of other production processes. In insulating oxide layers or in active regions of silicon, quantitative identification of dopants** and contaminants, in the parts-per-million to parts-

* French is chief of the Electronic Technology Division in the NBS Institute for Applied Technology. This article has been adapted from a talk given at the 15th anniversary meeting of the National Conference of Standards Laboratories.

** Dopants are minute amounts of impurities added to alter the properties of silicon to provide the characteristics required for device operation.

per-billion range, and of their distribution over fractional micrometer dimensions are required. Most of the physics of a device takes place within a micrometer or so of the surface!

In the future, the dimensions of entire transistors will approach a wavelength of light to meet, for example, computer requirements for increased speed and reduced power consumption in each logic function. The metal-oxide-silicon transistor of the future may have less than 200 dopant atoms in its 150 nanometer-long control channel. It may be manufactured using electron beam exposures of new polymer materials to define working areas, with its dopants introduced by ion implantation techniques. The control measurements for all of these processes must be economically feasible on a manufacturing line.

But there are already problems with the control measurements, even today before these extremes in design requirements are reached. Alternate silicon wafers in a single diffusion run may have high or zero yield of devices for unknown reasons. Processes which are more art than science go out of control and, lacking quantitative control over the materials involved and the processes themselves, the panic button is pushed. An enormous amount of frantic empiricism begins as the lost art is redeveloped and the process re-established. Procurement experts write specifications on hermeticity and water vapor content of devices, for example, to achieve reliability, but satisfactory test methods are not available. Those responsible for safety in large systems complain that there is no adequate way to electrically test individual elements in complex microcircuits such as microprocessors. And so it goes.

These are not simply matters of routine economic significance, hopefully to be solved by each company as a normal cost of doing business. They mean more to our nation and the taxpayer than that. Not only are they of concern with respect to our international technological leadership, but they are of concern to military and civilian users of electronics in this country.

The Department of Defense (DoD), long a leader in understanding the advances to be gained from the use of electronics, is much concerned about the cost of doing business with a high dependence on electronics. Electronic maintenance costs the

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Silicon based semiconductors have been the pacesetters for years and will continue to be so for the foreseeable future.

SEMICONDUCTORS

Over the last 20 years, semiconductor devices have revolutionized the engineering field of electronics so that today this field touches nearly every aspect of our lives. Semiconductors have greatly reduced the size, weight, and power consumption of electronic systems and have increased their performance and reliability. As a result, dramatic advances have been made possible in the fields of computer technology, telecommunications, space exploration, industrial controls, medical technology, the life sciences, chemistry, and physics.

Semiconductors help entertain us in our stereos, televisions, tape recorders, radios, and electronic games. They are used in cameras, digital watches and clocks, variable speed tools, and kitchen appliances. They make possible hand calculators and are at work in our automobiles. They help assure the safe and efficient control of air, train, and automobile traffic. They make possible modern computers which keep track of the myriad of accounts, records, and other information we routinely use every day.

Semiconductor devices range in size from tiny diodes that can fit on the head of a pin to large silicon-controlled rectifiers that consist of silicon wafers as large as 7 centimeters in diameter. These, with transistors, are the discrete semiconductor devices that are incorporated with other circuitry to switch and amplify electric currents and signals. Even greater size reduction, energy savings, and performance and reliability enhancement are possible by integrating entire electrical circuits onto a single silicon chip. As many as thousands of transistors and diodes with complex arrays of resistors and capacitors can be fabricated on a single chip only a few millimeters square. Some chips are small enough to slip through the eye of a needle.

Pentagon over $5 billion per year. Accident costs have risen as the result of failures of increasingly complex computers and components. DoD's ability to purchase custom, reliable devices to provide the competitive edge it requires for our national defense has led it to conclude that new attention must be given to improved measurement methods in manufacturing processes for two primary reasons: so that reliability can be built into devices made in the large quantities that provide economy-of-scale and so that devices can be designed and built in modest quantities and still be both reliable and affordable.

The significance of similar problems in the civilian sector is only beginning to be appreciated. There the impact will be felt in the reliability, safety, and economy of such large-scale applications as automobile electronics, computer controlled systems, and medical instrumentation.

Measurements that are meaningful, repeatable, and economical are needed for control on the production line.

Measurements that are meaningful, repeatable, and economical are needed for control on the production line. They must be backed up by specifications and tests and standards covering the material and equipment coming into the line, and they must be followed by screening tests on the finished product and by incoming inspection by the customer. Everyone claims to know all this, and even to practice it. So what is the problem?

Three points can be made in answering this question:

The first is that some practical measurement needs cannot be met because basic quantitative measurement technology is not available, even in standards or research laboratories.

As an example, consider the control that is necessary of dopants and contaminants in the micrometer-sized working region of a transistor. Quantitative measurements, backed up by standards, are not available to provide this information, despite the advent of powerful qualitative methods such as ion microprobes and other surface analysis tools. The Electronic Technology Division is attempting to provide a start in this direction, in work supported by the DoD's Advanced Research Projects Agency (ARPA) that is aimed at providing artifacts of known chemical content. These materials are produced in a silicon matrix by the same photolithographic processes and ion implantation used in making semiconductor devices. They are defined in content by independent analytical means (neutron activation) applied to companion samples.

The second point is that some practical needs are not being met because of gaps in the traceability chain, gaps which may occur near either end of the chain—on the production line or at NBS.

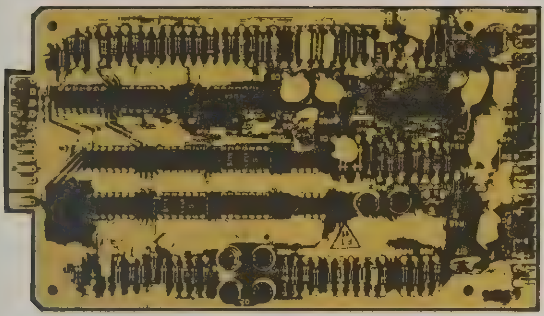
As an example of the former, consider the use of a test instrument duly calibrated by the in-house standards laboratory and traceable to the standard volt. The rub is that a fixture has been added by the user between the instrument and the device he is testing, and he and his customer cannot understand why they always disagree. What is lacking is some standard artifact for checking out the whole measurement system.

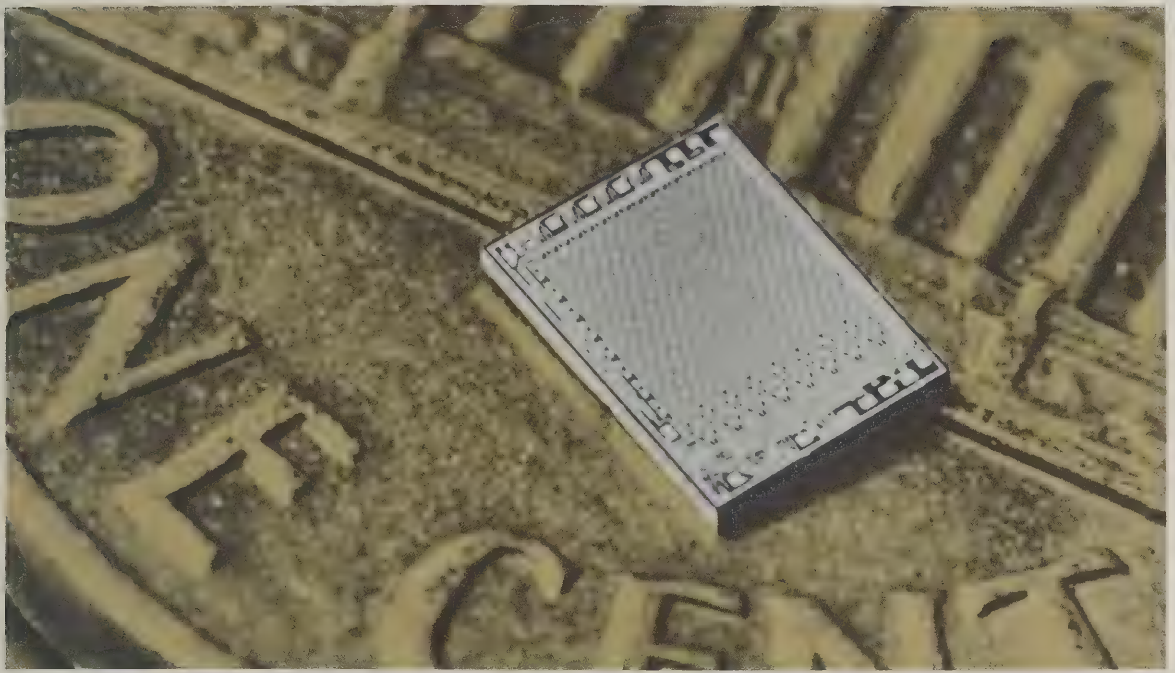
As an example of a break in the chain occurring at NBS, take the measurement of linewidths in a photomask used in patterning the structures in a semiconductor device. Five to twenty steps in the manufacture of a device require photomasks. Absolute dimensions on each mask, uniformity across a mask, and registration of the image on the device structure from masking step to masking step are required to tolerances of the order of fractions of a wavelength of light. Poor control of line width can adversely affect device yield. It certainly can affect marketplace exchanges of photomasks. Several million photomasks are used a year by semiconductor device manufacturers and untold millions of masking operations are performed.

Photomasks are sold by over two dozen small companies to device manufacturers. Photomasks are also made and used by the device maker and exchanged between the in-house maker and user. In either case the problem is similar: inability to agree on the measurements because the measurements cannot be standardized yet. What is needed now is a measurement standard for line width of one micrometer plus or minus 50 nanometers and the optical technology for properly using it.

Soon, the need will be for fractional micrometer standards. NBS has not been able to make these measurements. Line separations, yes; linewidths, no. But the Bureau will be able to do so soon. In a cooperative program, initiated by the Electronic Technology Division and carried out by this and two other NBS Divisions (Mechanics and Optical Physics), improvements in optical measurement understanding and procedures have been developed and artifacts in the micrometer range are expected to be available this year on a trial basis, with the fractional micrometer standards to follow.

The third point is that some practical needs are not being met because external influences on the measurement instrument or sensory transducer are





This tiny semiconductor is a complex maze of transistors on a single integrated circuit chip. It is a miniaturized version of a much larger array of electronics. The rapid advances in the design of semiconductors like this have made today's computers possible.

ignored, either inadvertently or because there is no available way to take them into consideration (usually for lack of information about the problem). The problem here is that calibrations are typically conducted under laboratory conditions that bear little resemblance to the real world environment of vibration, thermal transients, magnetic fields, and so on. There are many examples from semiconductor process control or in other types of manufacturing process control that could be used to demonstrate this point, but consider a totally different field this time: the case of some high-quality, high-priced pressure transducers for flight-test instrumentation. Suspecting that these devices might be affected by thermal transients to which they are occasionally exposed in use, a simple, quick screening test to check for such sensitivity has been developed. This work was done in the Electronic Technology Division at the request of the DoD Range Commanders Council. Using this new method to test representative devices of several types, including strain gauge and crystal-based transducers, it was found that apparent pressure shifts of 0.4 percent to 400 percent of full scale were observed solely as the result of thermal pulses with an energy density of 1.8 joules per square centimeter.

It has become abundantly clear that electronics is presenting a challenge to metrologists and is demonstrating an increasingly important need for advancements in the development and practice of practical, on-line measurements for a variety of social and economic reasons. Research is needed, to be sure; new methods and standards are required; and greater care is required in using the instruments that exist and have been calibrated in the traditional way.

NBS is responding to this challenge and need in its electronic technology program, where the goals are to develop cost-effective measurement technology for commerce (to specify electronic materials and devices), for industry (to control electronic device fabrication processes), and for government (to improve economy in procurement and application of electronic components and the systems which use them).

Those to whom the provision of good measurements is an important mission can help in responding to the measurement challenge of our age. Look at the practical measurement problems in your organization. Use your expertise to help solve them, and when you find gaps where new measurement methods are needed, call them to the attention of those who are responsible for developing them—in your organization or here at the National Bureau of Standards. □

Destroying to BUILD Better

Progressive collapse typically involves multi-level destruction seemingly out of proportion to an initial failure in a small part of the structure.

by Stan Lichtenstein*

WHEN a building collapsed recently at the National Bureau of Standards, its downfall was calmly observed and exhaustively documented.

The collapse was a setup job. Actually the "building" was a one-quarter scale model of one level of what was once a two-floor, partially completed parking garage in a Washington, D.C. suburban community. The real one had been accidentally reduced to ruins earlier when the adjacent 24 story-tower of a still-under-construction, high-rise complex toppled. Fourteen workmen were killed and 34 injured.

The stage directors of the Bureau's partial re-enactment—which took place in the Structural Testing Laboratory of the Center for Building Technology's (CBT) Structures Section—were interested in the original garage only as a prototype of widely used concrete construction—the unbonded, post-tensioned, flat-plate slab variety.

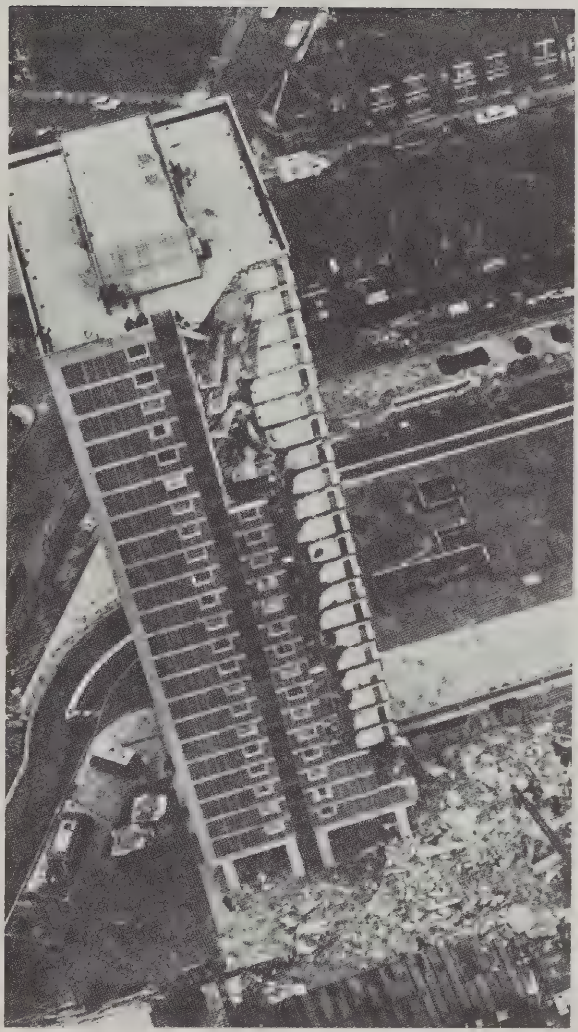
In such construction, the slabs are fabricated by casting the concrete over cables of steel set in plastic tubes to prevent bonding of the concrete to the cables. After the concrete hardens, the cables are pulled taut and elongated, transferring the stress to the concrete to compress it. The resulting structure has strength equal to or greater than reinforced concrete.

The NBS engineers carefully planned and executed a series of destructive tests of the scale model in order to see what they can learn about "progressive collapse" and its prevention in flat plate slab construction.

Progressive collapse involves failure of a small portion or element—a wall or column, for example—of a structure followed by a chain reaction of failures. Then the entire structure or a major portion thereof falls "like a house of cards."

In the case of the garage collapse which motivated the NBS experiment, a falling crane may have been partly responsible for the initial failure leading to total destruction. Progressive collapse can be triggered by any of a number of sudden-demand types of load—accidental impacts, foundation failure, stresses from faulty construction practices, gas explosions, bombings, extreme winds, earthquakes, floods, motor vehicle or aircraft collisions with buildings, and the like. This type of loading, which is not usually considered in structural design, is often referred to as an abnormal loading.

* Lichtenstein is a writer and public information specialist in the NBS Office of Information Activities.



The classic Ronan Point residential building collapse in London a decade ago began with a gas explosion in an 18th-floor corner apartment's kitchen.

Susceptibility of buildings to progressive collapse is a subject of growing concern because events examined by NBS resemble other incidents in various parts of the world. Accumulating evidence suggests that multistory buildings are too frequently designed without proper attention to progressive collapse resistance. A certain complacency among designers developed following World War II because steel or concrete framed multistory buildings in England had stood up well under bomb attacks, demonstrating that such framed structures could "bridge over the demolished" portion and escape more serious consequences. But builders have since

turn page

As increased loads are applied to the experimental slab, project director E. V. Leyendecker makes deflection measurements.

With collapse near, the model garage floor takes on the contours of a stormy ocean.

devised new and more economical multistory structural forms that may comply with established codes and yet offer less resistance to progressive collapse than earlier framed buildings. Complacency began to dissipate rapidly after a portion of London's precast concrete Ronan Point apartment building crumbled in 1968 as the result of a gas stove explosion in one tenant's kitchen.

In the past nine years, the United Kingdom, Canada, Germany, Sweden, Denmark, and the Netherlands have reconsidered their regulatory structural safety provisions with particular attention given to the phenomenon of progressive collapse.

Here in the United States, the Department of Housing and Urban Development in 1971 enlisted NBS for a detailed study of progressive collapse and abnormal building loads. The Bureau also provided technical support in the drafting of HUD's Operation Breakthrough structural design criteria for avoiding progressive collapse. A short statement alerting designers to the problem was included in *Minimum Design Loads in Buildings and Other Structures*, A58.1–1972, published by the American National Standards Institute (ANSI). And the City of New York, in an August 1973 amendment of its building code, specifically required that progressive collapse be avoided.

Such actions, here and abroad, represent a bebinning. The problem is now clearly recognized. But full understanding of the nature of progressive collapse, and determination of the best cost-effective measures to prevent it, are yet to be attained. Forthcoming analytical results of the NBS parking garage experiments will contribute to the research base from which solutions will be derived.

The staging of the collapse in the Bureau's Structural Testing Laboratory was a slowed-down, phased process. In a manner of speaking, the experimental collapse was done "in triplicate," for there was not one structure but three, each painstakingly fabricated by NBS engineers and technicians in the Bureau's Gaithersburg facilities.

The first NBS-manufactured slab was a "calibration" model, consisting of an isolated column with a surrounding portion of the garage "floor." The second was a "strip" model, consiting of a one-span by four-span section. The third was a "segment" model, consisting of a four-span by four-span section.

Under the direction of Dr. E. V. Leyendecker of the Structures Section, each of the three phases of testing, using its own specially tailored model slab, gave the experimenters virtual push-button control of the staged collapse. Leyendecker and his colleagues were, in effect, turning the collapse on and off at will. Sensitive instrumentation was used to make precise and sophisticated measurements of the whole, calculated process of destruction. Innumerable photographs were taken.

Each experimental slab was destructively tested for specific analytical purposes. In part, these purposes included:

Model No. 1 (single column and floor section)—

- A calibration check related to an American Concrete Institute code formula and recommendations for predicting "punching shear capacity,"

that is, the tendency of the forced column to punch its way through its floor connection

- Checking out the technique used to fabricate the model slabs, the instrumentation, and the loading system used in the experiment.

Model No. 2 (one-span by four-span section)—

- Observing what happens when a column supporting a floor edge fails. Would this propagate punching shear failures farther into the slab?

Model No. 3 (four-span by four-span section)—

- Analyzing the effects of various connected events, such as removal of edge and interior supports, how the load does or does not distribute itself, and the general propagation of the failure
- Observing the effects of detensioning the slab's steel cable inserts
- Assessing the total demolition process.

Fabrication of the model slabs was a considerably more challenging task than construction of a real parking garage floor would have been. The models, of course, had to be appropriately scaled so that the NBS Structural Testing Laboratory's main test floor could accommodate them. But many other considerations went into the scaling. There had to be a whole system of translations of the dimensional scale into other terms. What, for example, are the valid equivalents of the weights and forces exerted on the real garage when the model is one-quarter scale? These and other equivalencies had to be worked out on the basis of engineering, physical, and mechanical principles.

Granted that the model slabs could not be too big for the test laboratory, how far down toward the lower end of the dimensional scale could the experimenters go? Again, the necessary considerations were both theoretical and practical. The decision to go with a model slab slightly less than 48 mm (1 ⅞ inches) thick and—in the No. 3 version—approximately 7.0 meters (23 ft) wide by 9.7 meters (32 ft) long was based partly on experienced judgment, partly on convenience of fabrication.

For the concrete mix, concrete with smaller than usual aggregates was selected as the one calculated to produce a model slab behaving like the prototype slab under the conditions of the experiment.

A central-core steel wire of a seven-strand spiral pattern cable was acquired to serve as a post-tensioning cable for the model slabs. It turned out to be too strong and didn't exhibit all the properties needed. Its coiled shape, as delivered, threatened to interfere with the desired stress-strain factors to be studied. Since suitable commercial ovens could not be located, NBS engineers set up their own small factory to make annealed straight wire for the experiment. At one point, Dr. Leyendecker experimented with an NBS welding machine, using it to pass current through the wire in an effort to induce certain properties. Eventually, every wire was systematically treated in this way.

Further imaginative planning and resourceful improvisation were applied to the mechanics of the experiment. The loading rig was specially designed to allow application of loads by pulling the slab from underneath. The special rig, by obviating the need for a large test frame overhead, afforded the experimenters a clear view from above of the placement and behavior of the slab during loading tests. Supplementary weight had to be added to the model before stressing the wires in order to maintain dead weight similitude in the model for ultimate strength load tests. Lead bricks—borrowed from the LINAC Operations Section of the Bureau's Center for Radiation Research—proved to be of perfect proportions and density for stacking on top of the slab.

The experimenters had more than one kind of question in mind as their phased tests proceeded. Collapse sequences were planned according to a plausible scenario of what could happen to any structure or what might have happened to the parking garage that served as the prototype structure for the model.

What emerges from the NBS parking garage experiment as analysis of the results is completed will be observed with interest by architects, construction engineers, and safety and code authorities in this and other countries.

Several principles are involved:

- That life safety is a foremost concern, and progressive collapse a threat to life.
- That buildings should have a reasonable level of structural integrity, providing alternate paths for destructive forces to flow through or around.
- That improved standards and provisions for avoiding progressive collapse can be formulated and applied without causing prohibitive expense as a result of overdesign.

With fresh insight from the NBS controlled laboratory experiment, a clearer perspective on some aspects of progressive collapse will be developed. New and better strategies for avoiding it should then be in prospect. □

COOPERATIVE RESEARCH IN DENTISTRY

*by Diedra Van Duzee**

"One out of every 10 dollars spent on dental care in this country goes for the production of full dentures, removable partial dentures, crown and bridge prostheses, and other devices for the repair or replacement of teeth," says Bob Bauer. Bauer, a metallurgist, is researching alloy-related problems at the National Bureau of Standards under the sponsorship of the National Association of Dental Laboratories.**

There are four types of substrate alloys used today for porcelain-fused-to-metal restoratives—gold based, gold-platinum-palladium based, palladium-silver based, and nonprecious alloys that use a nickel-chromium base. Bauer and NBS researchers are engaged in a comprehensive research program to evaluate the properties of these non-precious alloys for use in crown and bridge restoratives.

Bauer's first few months as a Research Associate were spent in commercial dental laboratories learning first-hand the problems involved in the fabrication of dental prostheses. He then visited some of the manufacturers of alloys to become familiar with the development and properties of the materials. Over 3,000 dental laboratories belong to the National Association, says Bauer, who recently surveyed these labs to find out what problems exist when a specific type of alloy is used in fabricating a dental prosthesis.

"Until January 1, none of the manufacturers labeled the composition of their noble metal alloys on the alloy packets supplied to the dental laboratories. The labs felt that they should know the noble metal content in the alloys they were buying," he says. Bauer had a role in the negotiation of an agreement to label the noble metal constituents of such alloys. He is now working to measure the surface roughness of dental castings, which affects how the prosthesis fits the patient. A measuring technique using a scanning electron microscope is being employed in this project.

Bureau research in dentistry began at the end of World War I at the request of the Surgeon General of the Army who faced difficulties in securing adequate dental care for his troops. The immediate problem—one of materials failure—was solved by NBS with the cooperation of a private dental laboratory. However, the research disclosed a mass of confusion and conflicting data in dental science. In later years, with the assistance of Research Associates from the American Dental Association and practicing dentists, a program was begun to define the physical and chemical properties of inlay materials, plasters, and waxes. These investigations culminated in specifications and standards that served both the dental profession and the dental industry.

"The newly created association with the dental laboratories establishes an important affiliation between NBS, a leading researcher of dental materials, and that part of the dental industry which must ultimately use these materials." says Bauer.

Before joining the Research Associate Program, Bauer was an assistant professor of metallurgy at Michigan State University. Through his experience here he is "learning about a totally new field that is extremely interesting." He sees the opportunity to contribute to the NBS program and to his sponsor on a long-term basis by fully exploring and exploiting this field.

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* Van Duzee is a staff writer for DIMENSIONS.

** Bauer is participating in the NBS Research Associate Program. The program has brought researchers from all areas of industry to NBS labs for over 50 years to work on projects of mutual interest—for mutual benefit. For information, contact Peter de Bruyn, Room A402 Administration Building, National Bureau of Standards, Washington, D.C. 20234. Phone: (301) 921-3591.

FIRST FEDERAL COMPUTER SECURITY STANDARD

*by Dennis K. Branstad**

The Data Encryption Standard (DES), recently approved by the Secretary of Commerce as a Federal Information Processing Standard, is the first federal computer standard that can be used to protect computer data. The standard, scheduled to become effective for federal agencies on July 15, 1977, is a product of NBS' Brooks Act responsibilities to provide uniform computer standards to improve the effective use of computers in the federal government.

The need for data protection has increased as the federal government and private sector organizations have become increasingly dependent upon computers and as accessibility to computers is facilitated by the use of remote terminals. Potential threats from the misuse of computer data include invasions of individual privacy and loss of funds and valuable information.

Data encryption was adopted as a technical solution to the problem of protecting data. The DES specifies an algorithm to be implemented in electronic hardware devices that encrypt (encipher) and decrypt (decipher) binary coded information. Encrypting data converts it to an unintelligible form called cipher. Decrypting cipher converts the data back to its original form. A key must be used to encrypt data. Only legitimate users will have that key for decrypting the cipher in order to use the information.

The standard is recommended for use by federal agencies in protecting information while it is being communicated between a terminal and a computer, between computers, or in certain circumstances while it is stored in off-line media. Because of the costs associated with implementing data encryption, initially only data that is extremely sensitive; valuable; or vulnerable to theft, modification, or disclosure may justify encryption. However, declining costs of the hardware devices may make encryption more readily available as a "standard option" in terminals and computers in the future.

The DES specifies that a risk-analysis should be performed under the direction of a responsible authority in each agency to determine potential threats to computer data. In addition to the risk-analysis, the costs of providing cryptographic protection with the DES as well as with alternative methods of data protection should be studied. Agency officials will be able to decide whether or not to use cryptographic protection and the DES based on the information collected in these studies.

Data encryption, however, is just one part of a comprehensive computer security program. Two previously issued Federal Information Processing Standards assist federal agencies in identifying areas of potential threat to computer security and in instituting protective measures. These are FIPS PUB 31, *Guideline for Automatic Data Processing Physical Security and Risk Management,* and FIPS PUB 41, *Computer Security Guidelines for Implementing the Privacy Act of 1974.*

Private sector organizations have shown considerable interest in the Data Encryption Standard. Recently, the American National Standards Institute Subcommittee on Bank Cards (X9A) recommended the use of DES when data encryption is used in the financial services environment. This includes banks, thrift banks, and savings and loan institutions.

To answer the many questions arising in federal agencies about the use of the standard and the risk analyses and cost studies recommended for its implementation, NBS held a Conference on Computer Security and the Data Encryption Standard on February 15 in conjunction with the Civil Service Commission. The administrative, physical, and system security measures needed for a comprehensive computer security program were discussed.

NBS plans to assist Federal users of the DES with both technical and administrative support. A Data Encryption Testbed has been established to provide a validation service for vendors of encryption devices. Validation certificates will be issued for devices meeting the standard, allowing vendors to sell to federal agencies devices identical to validated ones. Also NBS is preparing technical guidelines for implementing and using the DES.

Other federal agencies involved in implementing the DES are the National Security Agency, responsible for communications security, and the General Services Administration, responsible for procurement regulations for data processing equipment using the DES.

Existing Federal Information Processing Standards and Federal Telecommunications Standards will be used when the DES is employed in data communications applications. However, new standards will be needed for the electrical, mechanical, and functional aspects of communications security equipment using the DES. Standards for incorporating DES devices in terminals and communications processors and methods for generating and distributing encryption keys are other areas for future standards development.

At the recommendation of NBS, a technical subcommittee of the Federal Telecommunications Standards Committee (FTSC) has been established. The Subcommittee is drafting a standard for the use of DES in communications and plans to issue it as a joint Federal Telecommunications and Information Processing Standard.

NBS will continue to work with other government agencies and with the private sector in implementing the Data Encryption Standard and in developing the other security measures needed to protect computers and data.

* Dr. Branstad is a Computer Security Project Leader in the Institute for Computer Sciences and Technology.

INTERFEROMETRIC WAVEMETER FOR CW DYE LASERS DEVELOPED

Frequency-controlled cw dye lasers are producing dramatic, qualitative advances in laser spectroscopy. With the recently developed, scanning corner-cube interferometer (the Lambda Meter) described here, researchers will be able to tune such lasers conveniently and rapidly to the exact desired wavelength. The instrument provides sub-Doppler accuracy, adjustable resolution, and real-time wavelength display.

John L. Hall, Laboratory Astrophysics Division, Room A803, Joint Institute for Laboratory Astrophysics (JILA), Boulder, Colo. 303/499-1000, x-3126, and Siu-Au Lee Room A506, JILA, 303/492-7812, University of Colorado.

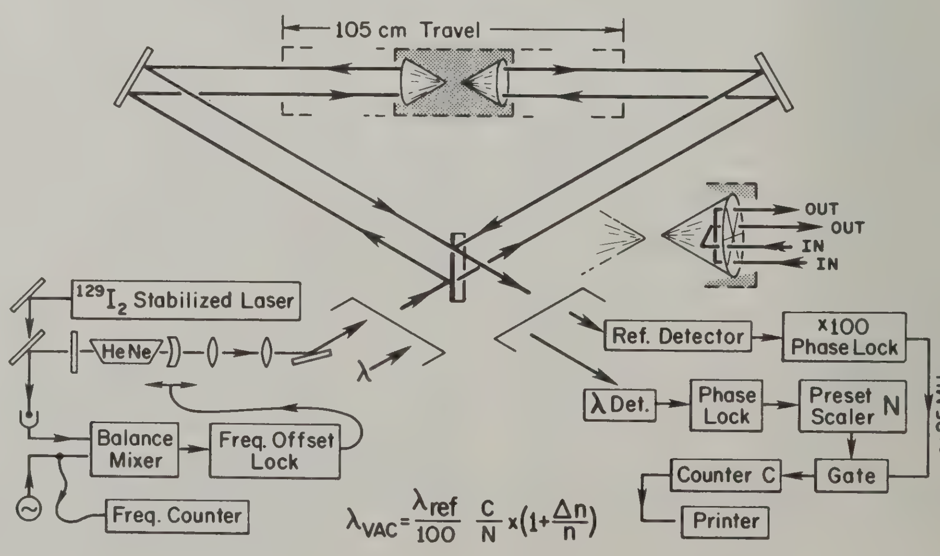
There has been rapid progress in cw dye laser capability, and techniques such as amplitude and frequency stabilization are becoming commercially available after long gestation in NBS labs and elsewhere. At present the central problem in using a tunable laser is to match the laser wavelength to that of the atoms or molecules of interest. This need led us to develop the Lambda Meter, a device which rapidly and conveniently measures the absolute wavelength of a cw dye laser. Now, within 2 minutes of resetting our laser's frequency we know its new wavelength to 7 digits and are in stable, single-mode operation.

The new instrument is an automatic fringe-counting interferometer which displays the real-time numerical value of a laser's wavelength. The novel phase-locked resolution-extension concept increases the interferometer's resolution by a factor of 100. We can obtain 4 updates per second at a resolution level of 2×10^{-7} (1/10 of a Doppler width). The wavelength readout has update rate choices corresponding to decade changes in resolution, the highest resolution being 2×10^{-9} (10 MHz in the visible) for the present apparatus. The absolute accuracy was at least 2×10^{-7} in our first saturated absorption experiments in neon.

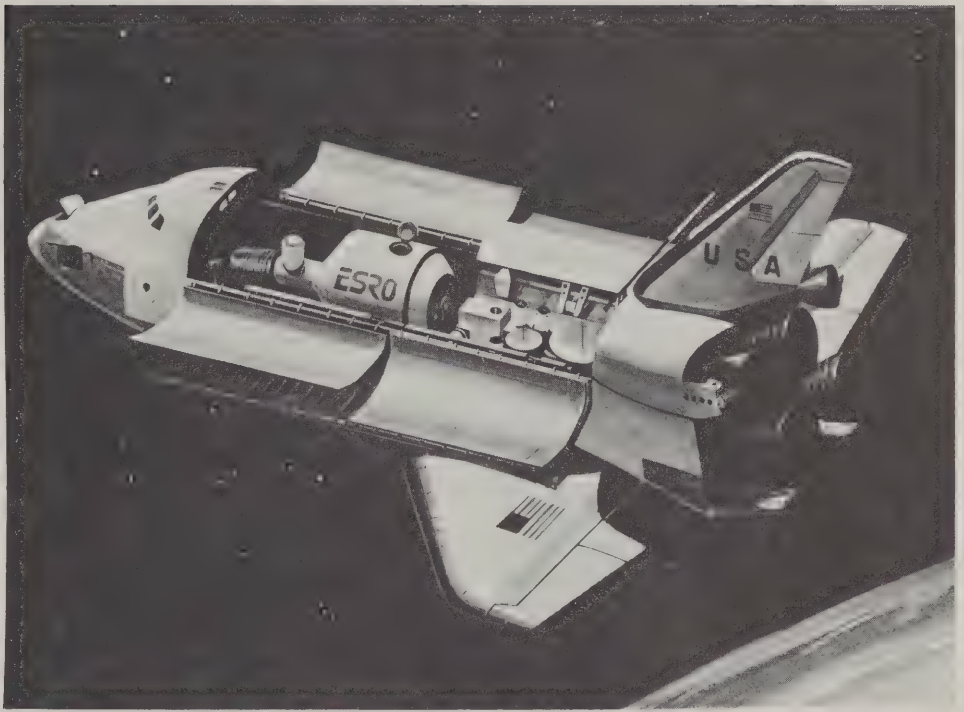
In Figure 1 the spatially separate reference (He-Ne) and unknown laser beams traverse a Michelson interferometer whose mirrors are corner-cube reflectors on a moving platform. (The inset shows the two beams entering and leaving a corner cube.) The emerging beams contain interference fringes which are counted by separate detector systems. Under suitable conditions, the equation in the figure relates the counter reading C to the vacuum wavelength λ_{vac} of the unknown laser. The preset scaler produces a gating pulse whenever it counts N fringes in the unknown beam. Presetting N gives us the choice in update rates, and hence resolution. The quantity Δn is the refractive index difference of air (or another medium) for the reference and unknown beams, and the integer 100 arises from the 100-fold frequency multiplication of the phase-lock resolution extender.

The corner cubes provide accurate retroreflection independent of possible angular wander of the carriage, so a simple translation mechanism will suffice. In the present version the $15 \times 15\text{-cm}^2$ moving carriage is supported on two "vee grooves" riding on a 48-in.-long quartz tube and stabilized by a "plane" riding on another quartz tube parallel to and 10 cm from the first. To provide smooth translational motion, the vee grooves and plane are actually formed by small ball bearings fitted with tires fashioned from thin-wall rubber tubing. (We choose not to use air bearing slides since we will want to operate the interferometer in helium or at reduced pressure ($\sim$130 Pa) to eliminate the air index-of-refraction dispersion.) A 5-W, 15-rpm reversible synchronous motor pulls the carriage by a ¼-mm woven metal fishing line. The 4-cm/s drive velocity has a noise of $\sim\pm6\%$ with a spectrum decreasing rapidly beyond $\sim$100 Hz. This low-frequency velocity noise causes interpolation errors $<$1/100 of a fringe due to the fast settling time of the phase-locked oscillators ($<$100 μs).

Figure—Schematic Diagram of Scanning Corner Cube Interferometer System ("Lambda Meter"). *The resolution is conveniently set by preset counting the ×1, ×10, or ×100 frequency outputs of the A detector's phase-locked oscillator.*



By feeding the reference laser fringes optically into both channels, the total electronic system precision was verified to be ± 1 count, independent of the resolution set by the preset scaler. The phase-lock loops provide signal/noise enhancement as well as increased resolution. Although 5-μW reference fringe power is sufficient for direct 1/100 fringe measurements, the dye laser's short-time noise would be a problem without stabilization. By averaging the jitter of a number of successive fringe zero crossings, the phase-lock system, through the bandwidth reduction, provides an improved interpolation algorithm.



A Spacelab module and pallet *fill the payload bay of this scale-model Space Shuttle orbiter. The pressurized, manned module (in bay near orbiter cabin) and the unmanned scientific instrument pallet (in bay near vertical tail) will be attached to and supported by the orbiter throughout a mission in Earth orbit. Spacelab, a joint venture of the National Aeronautics and Space Administration (NASA) and the European Space Research Organization (ESRO), is one of a number of different payloads that will be carried into space in the huge 4.5 meter (15 feet) in diameter by 18.3 meter (60 feet) long bay. Free-flying automated satellites may be placed in orbit and visited later for service, repair and retrieval. Satellites attached to propulsion stages can also be deployed. Becoming operational in 1980, the Space Shuttle orbiter will be launched vertically on an expendable liquid propellant tank and two recoverable, reusable solid propellant rocket boosters. Launch/landing sites for the orbiter will be Kennedy Space Center, Florida, and Vandenberg Air Force Base, California.*

DYNAMIC CALIBRATION METHODS DEVELOPED FOR SPACE SHUTTLE PRESSURE TRANSDUCERS

Manned space shuttles should be carrying payloads into space in the next decade and then returning to their earth launch/landing sites. Before final development testing of the first shuttle is completed, a control system will have to be set up to counter the vehicle's unstable movements. This instability is generated by pressure and flow fluctuations from the craft's liquid propellant engines—fluctuations that may make the vehicle move like a pogo stick. To develop the control system, accurate measurements of the oscillatory pressures must be obtained with pressure transducers. NBS researchers have developed two dynamic pressure sources for the calibration of the "pogo" pressure transducers. The work was performed for the National Aeronautics and Space Administration's Marshall Space Flight Center.

John S. Hilten, Carol F. Vezzetti, J. Franklin Mayo-Wells, Electronic Technology Division, A347 Technology Building, 301/921-3821.

By rotating a mercury-filled tube in a vertical plane at frequencies below 5 Hz, we are able to generate sinusoidal pressures up to 48 kPa, peak-to-peak. By vibrating the same mercury-filled tube sinusoidally in the vertical plane, we were able to extend the frequency response from 5 Hz to 100 Hz at pressures up to 140 kPa, peak-to-peak.

The sinusoidal pressure fluctuations can be generated by both methods in the presence of high static pressures up to 55 MPa. Overall calibration uncertainties are a function of both frequency and pressure amplitude but are probably no more than ± 6 percent and may be in the order of ± 4 percent for calibrations with the rotational source.

The requirements on the working fluid for the pogo transducer calibrations were such that mercury is the only suitable one for calibration at frequencies of 20 Hz and below; care must be taken because mercury's density, toxicity, and surface-tension properties make it a difficult liquid to handle safely. Above 20 Hz, silicone oil is preferred.*

* See NBS Technical Note 927, "Development of Dynamics Calibration Methods for Pogo Pressure Transducers."

SYNCHROTRON RADIATION FACILITY NOW AVAILABLE TO OUTSIDE USERS

A recent report by a National Academy of Sciences' Panel estimates that over the next 10 years the number of users of XUV synchrotron radiation will grow to a minimum of 480. One source of such radiation, located at NBS in Gaithersburg, Md., is now available to the general scientific community.*

Robert P. Madden, Optical Physics Division, A249 Physics Building, 301/921-2031.

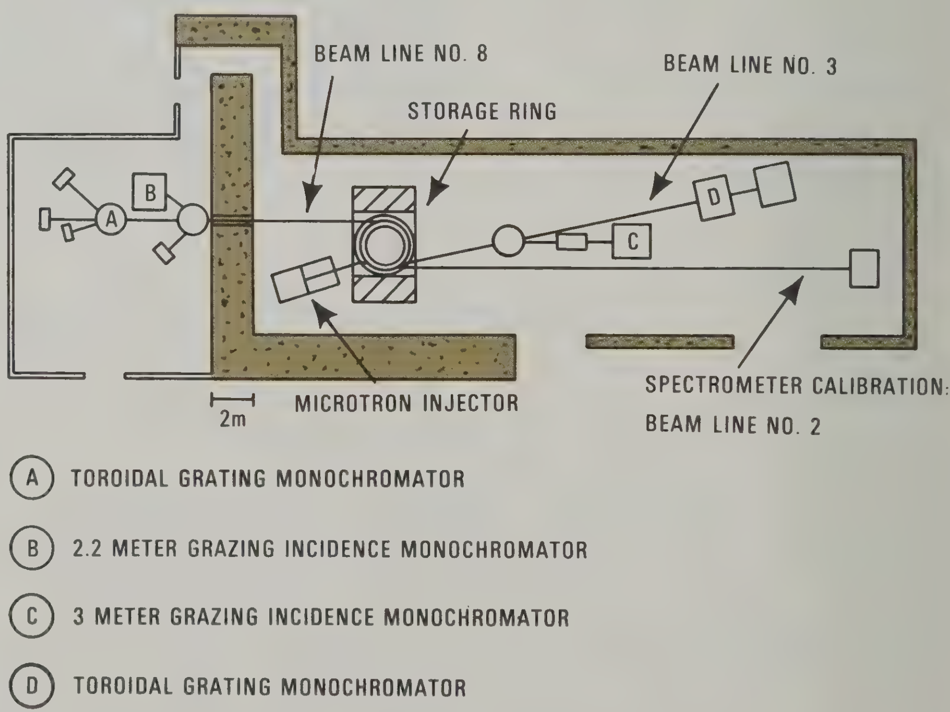
The Synchrotron Ultraviolet Radiation Facility (SURF) at the National Bureau of Standards is centered around a 250 MeV electron storage ring which serves as a dedicated source of synchrotron radiation. In recent operation this ring has exceeded all of its design specifications. Operation has taken place with electron energies up to 250 MeV, electron currents as high as 19 mA, and lifetimes as long as 6 hours.

Applications of extreme ultraviolet radiation recommended in the National Academy report, for which the NBS facility is particularly well suited, are XUV/absorption, reflectivity, and fluorescence spectroscopies; photoelectron spectroscopy; and photoionization cross sections. The absence of hard x-ray radiation (such as that produced by higher energy rings) facilitates the use of SURF in the XUV since elaborate shielding for the hard x-rays is not required, and there is no problem of radiation damage to mirrors and gratings. Also, overlapping order problems are reduced. Advantages of this storage ring facility over similar energy synchrotrons are that SURF allows an experimentalist to work on his apparatus close to the ring while the radiation is on, in complete safety, and that the beam intensity is a very slowly decreasing function of time rather than one with pulse to pulse changes, yielding higher intensity and greater stability.

At present, three vacuum beam lines have been established to carry the synchrotron radiation from the ring to experimental stations. Each line can simultaneously accommodate several experiments. More beam lines will be added to eight additional tangent ports existing on the ring as they are needed.

One beam line has been designed specifically for the radiometric calibration of spectrometers and photometers. A second beam line is designed to accommodate experiments that require the use of gases, including noble gases (but *not* hydrocarbons). A third line extends from the accelerator room into the control room. It is designed for the highest possible vacuum (10^{-10}-10^{-12} torr or 10^{-8}-10^{-10} Pa)
is done by ion pumps.

(Potential users of SURF should contact Madden during the earliest stages of experimental design so that compatibility with the NBS installations can be assured. —ed.)



SURF-II

*"An Assessment of the National Need for Facilities Dedicated to the Production of Synchrotron Radiation," 1976, available from Solid State Sciences Committee, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418.

DIELECTRIC MEASUREMENTS AT CRYOGENIC TEMPERATURES

NBS researchers are investigating certain polymers for use as insulation in high-voltage ac superconducting power transmission cables. The Energy Research and Development Administration is sponsoring the development of such cables to improve the efficiency of electrical power transmission.

Frederick I. Mopsik, Polymers Division, Polymers Building, Room B318. (301) 921-2939.

We have developed a cell for the measurement of the dielectric constant and loss of thin polymer tapes down to cryogenic temperatures. Six samples can be measured at the same time at any temperature from 4 K to 300 K. The cell is providing data necessary to choose an appropriate insulation for a superconducting power cable.

The design of a flexible ac superconducting power cable by Brookhaven National Laboratory has led to the search for polymer tapes that have electrical properties at cryogenic temperatures (6-8 K) that are compatible with the cable. These properties are a dielectric constant, ϵ, of less than 2.5 and a loss tangent (tan δ) of less than 30×10^{-6}. The difficult determination of such low levels of loss, especially in samples less than 100 μm thick, at cryogenic temperatures has led to a measurement program in the Polymers Division of NBS that has included the design and construction of a new dielectric cell.

The new cell has the ability to measure six samples 2 cm in diameter at the same time at any temperature from 4 K to 300 K. Each of the samples is maintained in a guarded, three-terminal arrangement. To minimize gap errors, the larger, upper electrode is mounted on a bellows so that pressure can be maintained against the samples. The cell is shown schematically in Figure 1.

The entire cell is mounted inside two surrounding sealed containers for isolation from the cryogenic liquid and temperature control. The inner container, which acts as an isothermal shield, is filled with low pressure He gas and is uniformly wrapped with a temperature control heater. The space between the two containers is evacuated. Resistance thermometers, mounted on the cell, are supplied with a constant current and the output voltage is used for both temperature measurement and control.

Electrical measurements are made with a bridge at 100 Hz and 1 kHz to a loss resolution of 1×10^{-6} in tan δ as verified by transfer from loss standards maintained by the Electricity Division. Sample data at 100 Hz for several different polyethylenes are shown in the graph, (Figure 2).

The data are currently being used in conjunction with structural studies on the tapes by Dr. F. Khoury of NBS to provide guidelines for BNL in selecting tapes having optimum dielectric and mechanical properties for use as insulation in superconducting power cables.

Figure 1—SCHEMATIC OF DIELECTRIC CELL

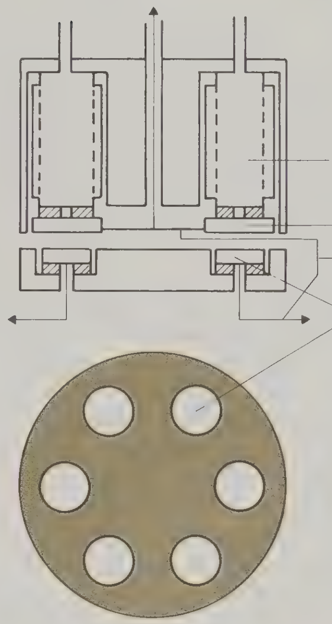
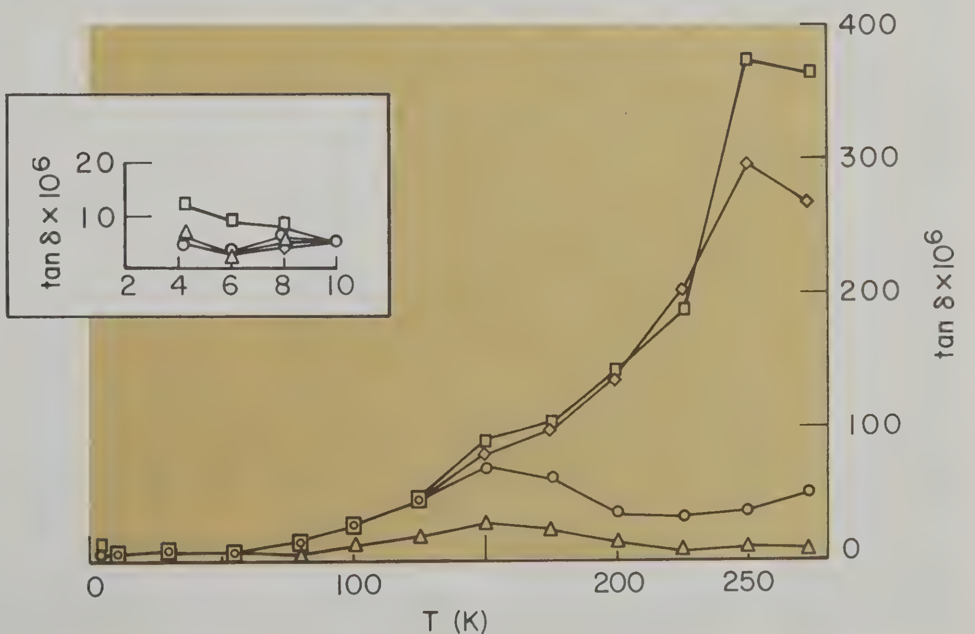


Figure 2—LOSS TANGENT AT 100 Hz OF SEVERAL POLYETHYLENES AS A FUNCTION OF TEMPERATURE



STANDARD REFERENCE MATERIALS FOR SCANNING ELECTRON MICROSCOPY

A Standard Reference Material and a Research Material have been prepared for scanning electron microscopy (SEM).

A complete list of SRM's and RM's available from NBS may be obtained from the Office of Standard Reference Materials, Room B311, Chemistry Building, (301) 921-2045.

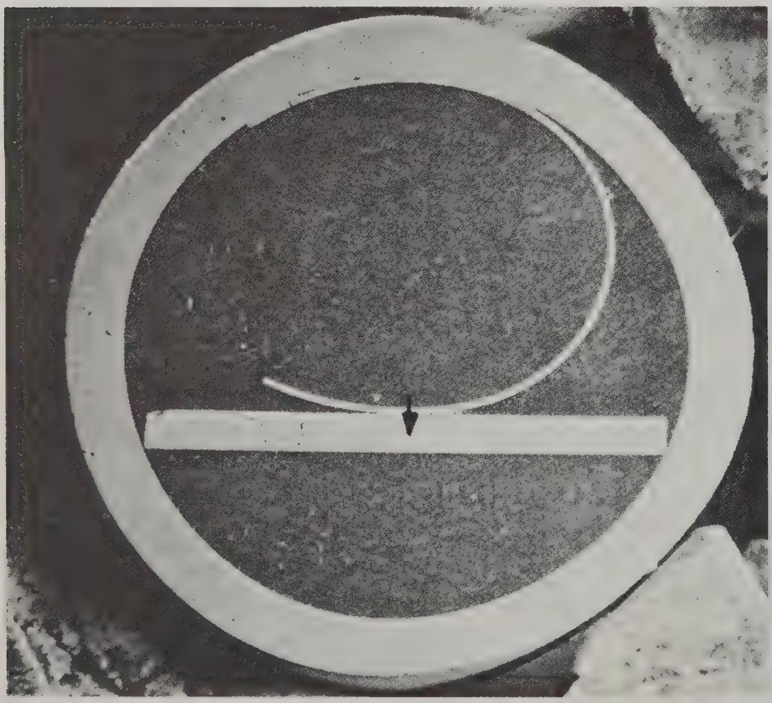
The Magnification Standard Reference Material, SRM 484, is designed for calibrating the magnification of a scanning electron microscope (SEM) from 1 kX to 40 kX. The nominal spacings between gold lines located in a nickel matrix range in several steps from 1 to 50 μm (see figure). Each specimen will be issued with a certificate of calibration for spacings of 1, 2, 3, 5, and 50 μm to an accuracy of 5% or better. The specimen is mounted in a copper-filled diallyl phthalate with an outer cylinder of 304 stainless steel 11 mm O.D. x 6.5 mm high. A detailed outline of the recommended procedures for the use of this specimen in the SEM, as well as a photomicrograph that shows the calibrated area is included with each SRM. This SRM should also prove to be a valuable tool in calibrating optical instruments.

The criteria for resolution test specimens for the SEM are severe. Many depend on various interactions between the electron beam and the specimen and include secondary emission, contrast, low contamination, beam and vacuum resistance, variable spacing, coating, rigid structure, beam deflection, and stability.

Some commonly used resolution specimens include silver or gold dendrites, aluminum-tungsten dendrites, pearlite in steel, thoria precipitates in nickel, osmium tetraoxide crystals, graphite, chromium oxides on magnetic tape, zinc oxide, etched opal, latex spheres, and marine micro-fossils. While no single sample meets all the criteria, the finely spaced dendritic structure of a metallic A1-W sample satisfies most of them.

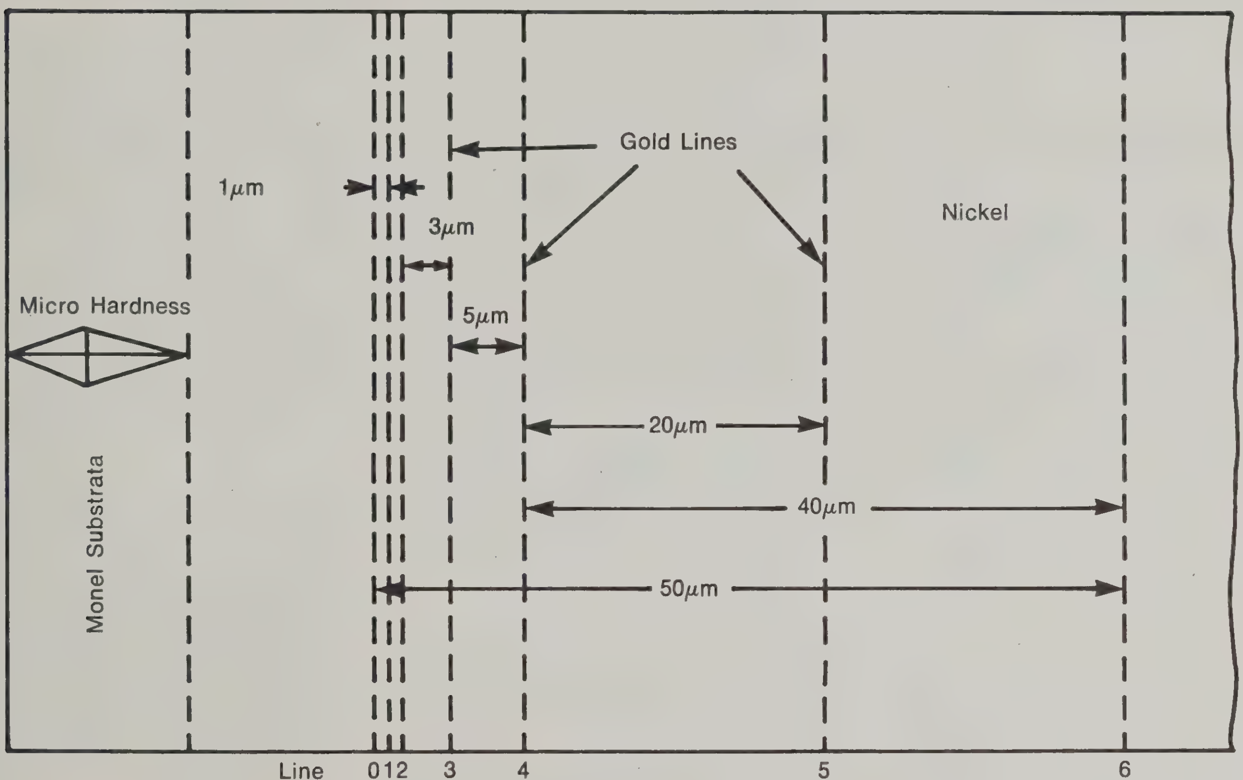
RM-100, SEM Resolution Test Specimen (A1-W), is an alloy of aluminum and tungsten exhibiting a fine dendritic structure (located at the surface of 5-mm diameter bead). These dendrites have a high secondary electron emission, and a high contrast that permits ease of stigmator adjustment for optimum resolution. There are no loose particles, it is nonmagnetic, vacuum clean, has no adverse reaction in the electron beam, no surface preparation or coating is required, and it has long-term structural stability. Also, RM-100 has a variable structure spacing suitable for both high and low resolution testing. This structure has been observed on extracted replicas in the transmission electron microscope (TEM).

The black arrow indicates certified areas of SRM 484 which is enlarged in the adjacent photograph.

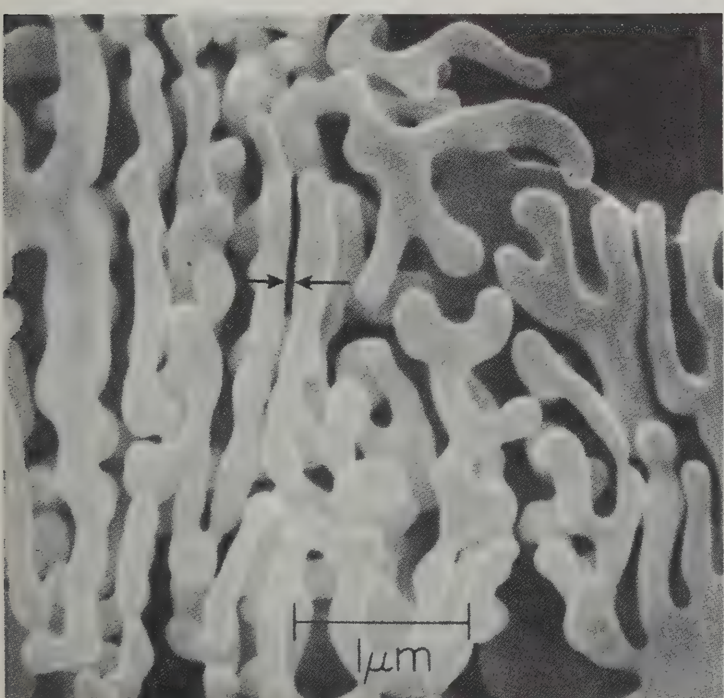


The microhardness indentation on SRM 484 indicates the area certified for distance between gold lines. (See diagram.)

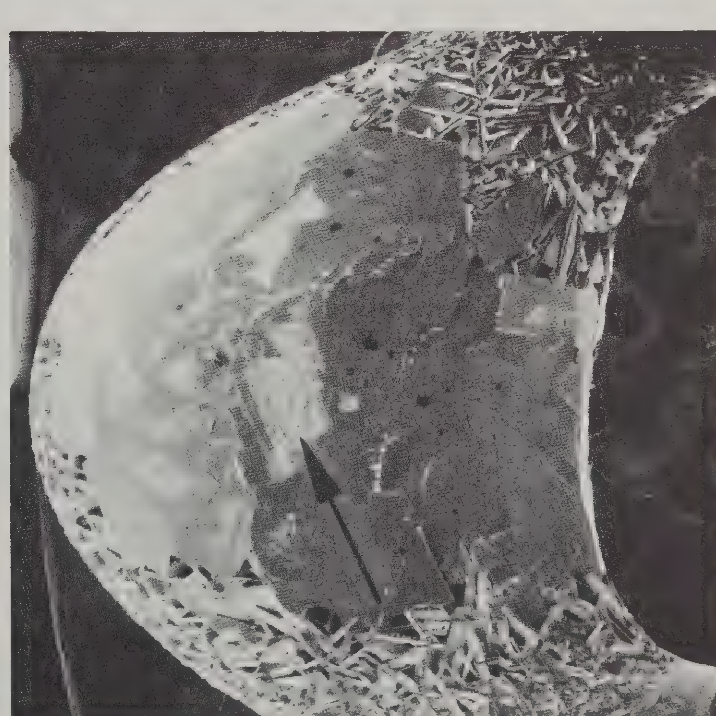
Figure—Schematic Diagram Showing the Nominal Distances Between Each of the Gold Lines in SRM 484.



The dark space noted by arrows demonstrates an approximate resolution of 50 nm (RM-100). RM-100 is supplied with a Report of Investigation that describes its recommended application and shows four typical micrographs for information and orientation.



Arrow shows location of dendrites on the surface of an aluminum-tungsten alloy bead (RM-100). A specific photomicrograph is provided with each specimen of RM-100 to verify the dendritic structure and its location.



CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.

COMPUTER SCIENCE AND STATISTICS SYMPOSIUM

The 10th Annual Symposium on the Interface of Computer Science and Statistics will be held April 14-15. The objective of the Interface is to provide a forum, through workshops, for statisticians, computer scientists, and numerical analysts to discuss important problems in the rapidly growing area of statistical computing. The workshop structure, bringing together as it does a variety of people from different disciplines, is an effective mechanism for consolidating and rapidly disseminating technical advances and for identifying important problems whose solution would benefit both statistics and computer science.

Recent Interface symposia have been well-attended and have attracted participants from all over the United States and from Canada as well. The 10th Interface will reinforce this national and international character. The Cochairmen are Dr. David Hogben, Statistical Engineering Laboratory, Applied Mathematics Division, and Dr. Dennis W. Fife, Chief, Computer Science Section, Systems and Software Division. The Interface will have an internationally known Keynote Speaker, Anthony Ralston (SUNY, Buffalo), six workshops with invited speakers, and at least two poster sessions for contributed papers. The two-day conference will have three workshops on each day.

Workshops

1. Large Data Files. Chairperson: Gordon Sande, Jr., Statistics Canada.
Various problems associated with the processing of substantial bodies of data will be addressed. The discussants will vary from practitioners of this difficult art to developers of new technologies which may be appropriate. The emphasis will be on "messy data" obtained under incompletely controlled situations rather than the more classic problems of tabulation on well structured large data bases.

2. Numerical Analysis Analysis in Statistics. Chairperson: Richard H. Tapia, Rice University.
This workshop will be concerned with the exchange of ideas and experiences gained from past numerical analysis/statistics interface activity with the goal of determining directions for future interface education and research.

3. Graphics. Chairperson: Jane F. Gentleman, University of Waterloo.
The workshop will be concerned with two topics: (1) Choice of graphics hardware; and (2) Human engineering in graphics software.

4. Maintenance and Distribution of Statistical Software. Chairperson: Mervin E. Muller, World Bank.
(1) The aims of this workshop are to: present significant technical ideas which influence the maintenance of existing or proposed statistical software; (2) encourage a dialogue among computer scientists and statisticians on aims, accomplishments, and unmet needs related to the maintenance of statistical software; (3) present a roundtable of leading specialists and the approaches, experiences, and problems of the distribution of statistical software; and (4) obtain an open discussion of the needs and views of how to distribute statistical software.

5. Nonlinear Models. Chairpersons: John E. Dennis, Jr., Cornell University, John M. Chambers, Bell Laboratories.
This workshop will focus on important new material on the fitting and analysis of nonlinear models and encourage dialogue between statisticians who use nonlinear models and computer scientists who develop numerical and other techniques for handling them. In particular, users of nonlinear models will be encouraged to discuss problems in their practical experience and to share their evaluations of the important challenges to more successful use.

6. Evaluation of Statistical Software. Chairpersons: Ivor Frances, Cornell University, Richard M. Heiberger, University of Pennsylvania.
The workshop will concern: (1) Statistical program packages for small computers; and (2) Computing approaches to the analysis of variance from unbalanced data.

For further information contact: Dr. David Hogben, Statistical Engineering Laboratory, Room A337 Administration, 301/921-2315.

CONFERENCE CALENDAR

*March 21-22
AUTOMATIC RF TECHNIQUES GROUP, NBS, Gaithersburg, MD; sponsored by NBS; contact: George Rogers, B310 Technology Building, 301/921-3621.

March 28-31
NEUTRON STANDARDS SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS; contact: European scientists Dr. Horst O. Kiskien, 014/58.94.21, Central Bureau Voor Nucleaire Metingen, B-2440 Geel, Steenweg Naar Retie, Belgium. Other participants contact: NBS, Dr. Charles D. Bowman or Dr. Allan D. Carlson, B119 Radiation Physics Building, 301/921-2234.

April 14-15
10TH ANNUAL SYMPOSIUM ON THE INTERFACE OF COMPUTER SCIENCE AND STATISTICS, NBS, Gaithersburg, MD; sponsored by NBS; contact: David Hogben, A338 Administration Building, 301/921-2315.

*April 18-19
WORKSHOP ON THE ESTIMATION OF THE PROPERTIES OF FLUID MIXTURES, NBS, Gaithersburg, MD; sponsored by NBS; contact: Dr. Max Klein, A105 Physics Building, 301/921-2533.

*April 20-21
SYMPOSIUM ON APPLICATION OF SPACE FLIGHT IN MATERIALS SCIENCE AND TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS and NASA; contact: Dr. Elio Passaglia, B266 Materials Building, 301/921-2822 or Dr. Shirleigh Silverman, A402 Administration Building, 301/921-3591.

April 23-26
COMPUTERS IN ACTIVATION ANALYSIS AND GAMMA-RAY SPECTROSCOPY, NBS, Gaithersburg, MD; sponsored by NBS, American Nuclear Society, American Chemical Society, ERDA and U. of Puerto, Puerto Rico Nuclear Center, contact: B. Stephen Carpenter, B108 Reactor Building, 301/921-2167.

April 25-28
LOW FREQUENCY ELECTRICAL MEASUREMENTS SEMINAR, NBS, Gaithersburg, MD; sponsored by NBS; contact: Ronald F. Dziuba, A247 Metrology Building, 301/921-3806.

May 10-12
SEVENTH SYMPOSIUM ON THERMOPHYSICAL PROPERTIES, NBS, Gaithersburg, MD; sponsored by NBS and the American Society of Mechanical Engineers; contact: Ared Cezariliyan, Room 124, Hazard Building, 301/921-3687.

May 16-18
CONFERENCE ON CORROSION OF METAL IN BUILDINGS, NBS, Gaithersburg, MD; sponsored by NBS; contact: Dr. G. Frohnsdorff, B350 Building Research Building, 301/921-3458 or Dr. J. Kruger, B252 Materials Building, 301/921-2094.

*May 17-19
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry Burnett, B260 Materials Building, 301/921-2813.

May 19
TRENDS AND APPLICATIONS SYMPOSIUM COMPUTER SECURITY AND INTEGRITY, NBS, Gaithersburg, MD; sponsored by NBS; and IEEE Computer Society; contact: Marshall Abrams, B212 Technology Building, 301/921-2601.

June 2
SYSTEMS AND SOFTWARE: OPERATIONAL RELIABILITY AND PERFORMANCE ASSURANCE; 16th Annual Technical Symposium, NBS, Gaithersburg, MD; sponsored by the Association for Computing Machinery, Washington, D.C. chapter, and NBS. Contact: Stuart Katzke, A265 Technology Building, 301/921-3861.

**June 13-15
CONFERENCE ON ULTRASONIC TISSUE CHARACTERIZATION, NBS, Gaithersburg, MD; sponsored by NBS; contact: Melvin Linzer, A329 Materials Building, 301/921-2858.

August 9-11
FIFTH SYMPOSIUM ON THE SIMULATION OF COMPUTER SYSTEMS, NBS, Gaithersburg; sponsored by NBS and the Special Interest Group on Simulation of the Association for Computing Machinery; contact: Paul Roth, B250, Technology Building, 301/921-3545.

September 21-23
SYMPOSIUM ON ROOFING TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS and the National Roofing Contractors Association; contact: Robert G. Mathey, B348, Building Research, 301/921-3407.

*September 28-30
DATA ELEMENT MANAGEMENT SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and ANSI Committee X3L8; contact: Hazel McEwen, B226 Technology Building, 301/921-3157.

*October 11-13
MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS, Energy Research and Development Administration, Electric Power Research Institute; contact: S. J. Schneider, B303, Materials Building, 301/921-2893.

*November 1-3
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored NBS and MFPG; contact: Harry C. Burnett, B260 Materials Building, 301/921-2818.

*December 5-7
WINTER SIMULATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, Operations Research Association of America, the Institute for Industrial Engineers, and the Society for Computer Simulation; contact: Paul F. Roth, B250 Technology Building, 301/921-3545.

* New Listing.
** This conference was originally scheduled for June 6-9.

APPLICATIONS OF THERMOGRAPHY FOR INDUSTRIAL ENERGY CONSERVATION DESCRIBED

Applications of Thermography for Energy Conservation in Industry, Hurley, C. W., and Kreider, K. G., Nat. Bur. Stand. (U.S.) Tech. Note 923, 31 pages (Oct. 1976), SD Catalog No. C13.46:923, 75 cents.

The use of infrared thermography as a tool in industrial energy conservation programs is described in a publication titled *Applications of Thermography for Energy Conservation in Industry*. The publication discusses the fundamentals of thermography and how thermographic surveys can be performed in industrial plants.

It also discusses the results of 16 such surveys by teams of NBS engineers and how the information obtained was useful in pinpointing and correcting energy losses. The plants in the NBS survey included tire manufacturing, cement making, copper refining, forging, and heavy equipment manufacturing.

However, the publication points out that the technique is applicable to many other industrial areas. Because of the significant information gained in these surveys, the authors of the publication highly recommend the use of infrared thermography as a tool in industrial energy conservation programs.

Thermography has been developed as a tool to measure the temperature of various types of surfaces. Notable applications include thermal detection of diseases such as cancer and circulatory problems in human beings, aerial land mapping of hot surfaces to detect thermal pollution and geological formations, and remote scanning to buildings to detect heat losses. More recently, the technique has been used to detect defects in high amperage electrical connections, transformers, and steel processing furnaces.

Buildings on these technologies, NBS engineers adapted the methodology to survey heating systems in industrial plants, in addition to the electrical and mechanical systems, to find areas where energy conservation actions could be applied. The survey was found to be an excellent method to detect environmental heat losses in process equipment and auxiliary systems.

The survey was also useful for detecting "hot spots" resulting from problems in the basic insulation design, flaws in the insulation, and maintenance errors. Many hot spots indicated malfunctions in the equipment such as leaking valves, leaking electrical components, failures in materials and components in invisible areas of the equipment, overheated bearings, and the like. The information gained from the surveys helped engineers to develop priorities, estimate the magnitude of the heat loss due to a given technique defect, and take corrective action.

CRITICAL SURVEY OF DATA SOURCES ON ELECTRICAL AND MAGNETIC PROPERTIES OF METALS ISSUED

The National Bureau of Standards has published the fourth in a series of data reference guides for researchers, manufacturers, engineers and other users of metals. *Critical Surveys of Data Sources: Electrical and Magnetic Properties of Metals* is a directory of authoritative sources of numerical data on electrical and magnetic properties of metals with emphasis on commercial alloys. It will be particularly useful to engineers involved in the design of equipment where these properties of metals must be known. The publication is available from the U.S. Government Printing Office, Washington, D.C. 20234, for $1.55 a copy (add 25 percent for foreign mailing). Order by SD Catalog No. C13.10:396-4.

Fifty-nine sources, including handbooks and other publications, information centers, trade associations and technical societies are described in the survey in detail. The survey includes information on the properties and materials covered, criteria used in the selection of data, size of data bank, cost of data access if any, and other pertinent details.

The survey was compiled under the sponsorship of the NBS Office of Standard Reference Data by M. J. Carr, R. B. Gravert, R. L. Moore, H. W. Wawrousek and J. H. Westbrook of the General Electric Company, Schenectady, NY.

The survey should help researchers determine what significant properties are generally available on important materials, what group of materials might provide a representative list of well documented property data sets; what property determinations are most conspicuously lacking; and what existing compilations might afford the best base for building a standard reference data set for electrical and magnetic properties.

The other three reference books in the series of critical surveys of data sources are:

- *Critical Surveys of Data Sources: Mechanical Properties of Metals,* R. B. Gravert, R. L. Moore and J. H. Westbrook, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, SD Catalog No. C13.10:396-1, $1.25.
- *Critical Surveys of Data Sources: Ceramics,* D. M. Johnson and J. F. Lynch, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20234, SD Catalog No. C13.10:396-2, $1.25.
- *Critical Surveys of Data Sources:* Corrosion of Metals: R. B. Diegle and W. K. Boyd, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20234, SD Catalog No. C13.10:396-3, $1.30.

ACCURACY IN TRACE ANALYSIS PROCEEDINGS PUBLISHED

How accurate are measurements of chemicals that are present only in very small quantities in foods, tissues, water, air and other materials? What factors contribute to accurate measurements?

OF THE NATIONAL BUREAU OF STANDARDS

How can the reliability of trace chemical measurements be improved? These and other questions are examined in a new publication entitled "Accuracy in Trace Analysis: Sampling, Sample Handling, Analysis." The two volume hard cover publication contains 100 papers presented at the 7th Materials Research Symposium sponsored by the NBS Institute for Materials Research, October 7 to 11, 1974. At that symposium, 400 scentists from 17 countries discussed the latest information available on trace chemical analysis.

The symposium proceedings contain descriptions of techniques, methods and extensive references related to making analytical measurements in trace chemistry. It thus provides a valuable guide for solving everyday analytical problems. In addition, several papers in the proceedings review requirements for accurate measurements of trace chemicals by regulatory agencies that use such measurements to enforce standards limiting air and water pollutants and food contaminants.

The proceedings contain contributed as well as invited papers by officials and scientists of NBS, the Food and Drug Administration, the Environmental Protection Agency, the Center for Disease Control, and various industry and private laboratories of the United States and abroad.

NBS Special Publication 422, "Accuracy in Trace Analysis," costs $20 for the two volumes ($25 for foreign mailing).

Electronic Technology

Bullis, W. M., Ed., *Semiconductor Measurement Technology. Progress Report, July 1 to December 31, 1975*, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-25, 87 pages (Oct. 1976) SD Catalog No. C13.10:400-25, $1.45.

Energy Conservation and Production

Hurley, C. W., and Kreider, K. G., *Applications of Thermography for Energy Conservation in Industry*, Nat. Bur. Stand. (U.S.), Tech. Note 923, 31 pages (Oct. 1976) SD Catalog No. C13.46: 923, 75 cents.

Fluids: Liquids, Gases and Plasmas

Moldover, M. R., Hocken, R. J., Gammon, R. W., and Sengers, J. V., *Overviews and Justifications for Low Gravity Experiments on Phase Transition and Critical Phenomena in Fluids*, Nat. Bur. Stand. (U.S.), Tech. Note 925, 99 pages (Oct. 1976) SD Catalog No. C13.46:925, $1.70.

Metrology: Physical Measurements

Hsia, J. J., *Optical Radiation Measurements: The Translucent Blurring Effect—Method of Evaluation and Estimation*, Nat. Bur. Stand. (U.S.), Tech. Note 594-12, 31 pages (Oct. 1976) SD Catalog No. C13.46:594-12, 75 cents.

Venable, W. H., Jr., Hsia, J. J., and Weidner, V. R., *Optical Radiation Measurements: Development of an NBS Reference Spectrophotometer for Diffuse Transmittance and Reflectance*, Nat. Bur. Stand. (U.S.), Tech. Note 594-11, 47 pages (Oct. 1976) SD Catalog No. C13.46:594-11, $1.15.

Standard Reference Data

Carr, M. J., Gavert, R. B., Moore, R. L., Wawrousek, H. W., and Westbrook, J. H., *Critical Surveys of Data Sources: Electrical and Magnetic Properties of Metals*, Nat. Bur. Stand. (U.S.), Spec. Publ. 396-4, 92 pages (July 1976) SD Catalog No. C13.10:396-4, $1.55.

Other Subjects of General Interest

Sheridan, T. B., Ed., *Performance Evaluation of Programmable Robots and Manipulators. Report of a Workshop Held at Annapolis, Md., October 23-25, 1975*, Nat. Bur. Stand. (U.S.), Spec. Publ. 459, 213 pages (Oct. 1976) SD Catalog No. C13.10:459, $3.40.

Publications listed here may be purchased at the listed price from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Michofiche copies are available from the National Technical Information Service, Springfield, Va. 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

NEWS BRIEFS

NBS ROLE IN RESOURCES USE/RE-USE NBS has gained new responsibilities in materials conservation and recycling under the Resource Conservation and Recovery Act of 1976. The act promotes the protection of public health and the environment and the conservation of valuable materials and energy resources. A secondary goal is to increase the rate of resource recovery of materials and energy from the 126 million metric tonnes of municipal waste currently being discarded yearly in the United States. The Department of Commerce, acting through NBS and with national standards-setting organizations, will publish guidelines no later than October 20, 1978, for developing specifications for the different classes of materials to be recovered from waste. These materials include ferrous and nonferrous metals, glass, and refuse-derived fuels. The specifications will involve the physical and chemical properties and characteristics of recovered materials.

BREAKDOWN OF FLUOROCARBONS DEMONSTRATED. A possible means of destruction of halocarbons by sunlight in the lower atmosphere has been demonstrated for the first time in laboratory experiments conducted at NBS in Gaithersburg, Maryland. Chemists Pierre J. Ausloos and Richard E. Rebbert report that solar radiation of wavelengths which reach the earth's lower atmosphere (troposphere) can break down fluorocarbon 11, fluorocarbon 12, and carbon tetrachloride if the chemicals are first adsorbed onto sand or quartz. The findings provide the first laboratory evidence that a mechanism exists for breaking down these industrially important halocarbons by light in the troposphere.

CANDIDATES WANTED FOR RESEARCH GRANTS. The National Bureau of Standards will award two research grants this year to scientists in academic institutions for work in the field of precision measurements and the determination of fundamental physical constants. The grants, worth $25,000 per year, may be renewed for up to two additional years. Prospective candidates must submit summaries of their proposed projects and biographical information to NBS by April 15 to be considered for these grants, which run from October 1, 1977 through September 1978. Contact: Dr. Barry N. Taylor, Chairman of the NBS Precision Measurements Grants Committee, Bldg. 220, Room B258, National Bureau of Standards, Washington, D.C. 20234, 301/921-2701.

PAMPHLET TO HELP HOMEOWNERS SELECT SMOKE DETECTORS. A free publication from NBS, called "Smoke Detectors...What They Are And How They Work," answers most commonly asked questions about selection and placement of smoke detectors in the home. Single copies are available by writing to "Detectors," Consumer Information Center, Pueblo, Colorado 81009. For information about ordering multiple copies write to Division 440, National Bureau of Standards, Washington, DC 20234.

NEXT MONTH IN

DIMENSIONS NBS

Americans have a heritage to preserve. Part of that heritage was built of adobe by Indians and missionaries hundreds of years ago. Some of their architecture is standing today, and hopefully it will still be intact for future generations to enjoy. The March issue of DIMENSIONS will discuss efforts to protect these historic structures from further decay.

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary
Betsy Ancker-Johnson, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Acting Director

Prepared by the NBS Office of Information Activities
Washington, D.C. 20234
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Hank Glittenberg: page 18.

The National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their effective application for public benefit. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method development, and standards writing. DIMENSIONS/NBS describes in technical and general terms results of NBS activity in areas of national concern such as energy conservation, fire safety, computer applications, environmental protection, materials utilization, and consumer product safety and performance. The functions of NBS are divided into four major Institutes: Institute for Basic Standards, Institute for Materials Research, Institute for Applied Technology, and Institute for Computer Sciences and Technology.

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